

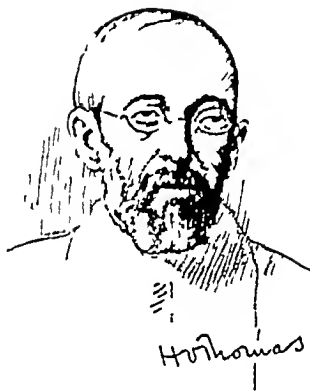


Dedicated

to



*Lester*



*H. Thomas*



*W. H. Auden*

For their work continueth, And their work continueth  
Broad and deep continueth, Greater than their knowing "

RUDYARD KIPLING



# THE JOURNAL OF BONE AND JOINT SURGE

representing the science and practice of  
orthopaedic surgery in the United States of America  
and the Commonwealth of British Nations

## OFFICIAL PUBLICATION OF THE

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# The Journal of Bone and Joint Surgery

## HIS MAJESTY THE KING

Long ago His Majesty graciously accepted an invitation to dine at the Reform Club, London, in company with British surgeons, leaders of British industry, and representatives of industrial welfare. He saw the first film ever produced on rehabilitation of the injured. It was an amateur's film, without sound or colour, measuring only sixteen millimetres, but the King was keenly interested in the demonstration of patients whose fractured wrists and plastered limbs did not prevent them making beds and peeling potatoes, whose fractured ankles did not deter them from walking many miles in plaster, and whose fractures of the spine did not limit the vigour of spinal muscle exercise. At that time there was little interest in the treatment of bone and joint injuries, it was a neglected part of surgery. The 1935 report of a fracture committee of the British Medical Association was revealing, disturbing, and even startling. A high proportion of fractures caused permanent disability. His Majesty's Government appointed an inter-departmental committee to investigate and report. Organised services were studied in the fracture clinics of Manchester and Liverpool. The development of fracture clinics, orthopaedic departments, and accident services was recommended. An Accident Hospital was planned for Birmingham. Hey Groves, in one of his last endeavours, urged the claims of a great accident centre for London. There was progress—but it was slow—very slow.

Fracture centres and facilities for rehabilitation had been developed in 1914–18 by Robert Jones but they failed to survive. A second great war was needed to drive home the facts. In 1939 and 1940 the Royal Air Force, Army, and Emergency Medical Services were encouraged to develop segregated traumatic and rehabilitation units. The Ministry of Fuel and Power established rehabilitation centres for miners. The Battle of Britain inspired men to fly and fight with fractured limbs in plaster, pilots asked for a hollow to be cut in the palm of the plaster so that the throttle would not slip. Royal Air Force rehabilitation centres became a Mecca for those who were eager to see the speed with which recovery was possible after grave and multiple injuries. These centres of physical, occupational, and recreational therapy were emulated and improved upon in the United States, Canada, Australia, the Soviet Union, and elsewhere in the world. His Majesty visited such units in the vicinity of London and witnessed the intensive redevelopment of muscles by active exercise and faradic stimulation.

These were inspired days. Dramatic results were achieved in the Middle East, North Africa, and Italy. Men wounded on the Continent, and treated in the base hospitals of Britain within a few hours of injury, were returned urgently to the fighting line. Emergency treatment, continuity of supervision, after-care and rehabilitation were the order of the day—a day of inspiration and enthusiasm. But let us recall that in the 1914–18 war such services were developed, they were perfected, they were forgotten. In the 1939–45 war they were developed once more, they were perfected once more. Will they be forgotten once more? It depends upon the surgeons of the English speaking nations—the British Commonwealth, and the United States of America, with their colleagues in Europe, South America, and other continents. Will the ideals which inspired us during war be kept alive? Will surgeons co-operate in joint endeavour?



biceps tendon into an intra-articular ligament, and even how to treat recurrent dislocation by the bone-setter's manipulation. No single structure in or around the joint was immune from attack. We were expected to know the operations of Clairmont, Joseph, Ehrlich, Oudind, Hybmette, Rich, Eden, Bankart, Loeffler, Hoffmann, Mandle, Keller, Thomas, Wulffing, Henderson, Kellogg, Speed, Levic, Mialelet, Heymanowitsch, and Nicola. Even within the last ten years new modifications of technique have been described by Wahl, Hobart, Roberts, Kjell-Beigman, Rupp, Fiejka, Kapel, Janek, Ahlberg, Stenport, and Camitz, and it is with some diffidence that in this very number we record the special technique of the great surgeons Gilke, Putti, and Platt.

Such history indicates that we have indeed lived during the last twenty-five years "in the stimulus of a great period of operative orthopedic surgery" and that such stimulus, by concentrating the minds of surgeons upon technique, has carried with it the danger of neglecting fundamentals. The fact is that the pathological anatomy of recurrent dislocation of the shoulder joint was described very accurately more than sixty years ago. Even before 1890, BROCA and HARTMANN illustrated detachment of the glenoid labrum and capsule with stripping of periosteum from the front of the neck of the scapula, and a traumatic defect in the head of the humerus which allowed it to subluxate over the glenoid margin while still remaining within the capsule of the joint. But these essential pathological features were overlooked and forgotten, and in the course of a feverish search for new modifications of operative technique they were ignored. The attitude of many surgeons is illustrated by the most recently published review on the subject,<sup>4</sup> in which the reviewer suggests that the pathology is really unimportant and indeed "is irrelevant if Nicola's operation or one of its modifications are used, since this procedure does not aim to repair the anatomical defect." In the words of EVARTS Ambrose Graham: "There is over-emphasis on the art of surgery. There is neglect of the science of surgery. A man cannot be a good surgeon if he is not a good pathologist. What can we do to reinspire the spirit of John Hunter?"

The spirit of inquiry, and the study of basic problems, is clearly evident in each of the contributions in this number. BLUNDELL BANKART still believes that detachment of the glenoid labrum is the "essential lesion" and that injury to the head of the humerus is relatively unimportant. IVAR PALMER on the other hand believes that a defect in the humeral head is the essential lesion and that labral detachments are relatively unimportant. But the careful study of CRAWFORD ADAMS, and the investigations of EYRE-BROOK and GALLIE, make it clear that there is no one "essential" element in the pathology, any more than there is a single essential feature in the pathological anatomy of any dislocation, or recurrent dislocation, whether of the ankle, patella, hip, elbow, or spine. In all these joints, dislocation causes detachment of capsule from the periphery of the socket, sometimes fracture of the margin of the socket, and often compression injury of the dislocating bone, and any of these elements may predispose to recurrent dislocation if the first injury is not immobilised adequately. Similarly in the case of recurrent dislocation of the shoulder joint there is usually anterior capsular detachment from the glenoid, sometimes fracture of the glenoid margin, and often compression fracture of the head of the humerus. Detachment of the capsule and periosteum of the neck of the scapula is observed in 80 per cent of cases. As a rule there is associated contusion of the articular surface of the humerus, which with recurrent displacement becomes an increasingly important defect. In other cases damage to the humerus, even at the time of initial injury, is a compression fracture of such degree that alone, without anterior capsular stripping, it is responsible for 15 to 20 per cent of recurrent dislocations.

With the pathology thus clearly recognised the rational type of operation is clearly indicated. There are three underlying principles: 1. If there is an anterior capsular defect it must be closed by suture, or at least be buttressed by scar tissue or bone, 2. Whether there is a capsular defect or not, the extremes of external rotation movement must be

\* International Abstracts of Surgery (Surgery, Gynaecology, and Obstetrics (1947)) 85, 391

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**The Journal of  
Bone and Joint Surgery**





BUCKINGHAM PALACE

28th October 1947

my dear *Sir Reginald Watson-Jones,*

The King has heard with much interest of the proposal that a new Journal of Bone and Joint Surgery should be established, in which the Nations of the British Commonwealth will share with the United States of America the task of recording recent progress and of publishing new discoveries

His Majesty has always followed with close attention the development of Orthopaedic and Accident Surgery, and commands me to convey to you, as its first Editor, his best wishes for the success of this new venture, supported as it is by all the English-speaking peoples in collaboration for the welfare of mankind as a whole.

Yours very truly

Sir Reginald Watson-Jones,  
FRCS.

A handwritten signature in dark ink, appearing to read 'A. Lascelles', with a long, sweeping horizontal flourish underneath.

# The Journal of Bone and Joint Surgery

## HIS MAJESTY THE KING

Long ago His Majesty graciously accepted an invitation to dine at the Reform Club, London, in company with British surgeons, leaders of British industry, and representatives of industrial welfare. He saw the first film ever produced on rehabilitation of the injured. It was an amateur's film, without sound or colour, measuring only sixteen millimetres, but the King was keenly interested in the demonstration of patients whose fractured wrists and plastered limbs did not prevent them making beds and peeling potatoes, whose fractured ankles did not deter them from walking many miles in plaster, and whose fractures of the spine did not limit the vigour of spinal muscle exercise. At that time there was little interest in the treatment of bone and joint injuries, it was a neglected part of surgery. The 1935 report of a fracture committee of the British Medical Association was revealing, disturbing, and even startling. A high proportion of fractures caused permanent disability. His Majesty's Government appointed an inter-departmental committee to investigate and report. Organised services were studied in the fracture clinics of Manchester and Liverpool. The development of fracture clinics, orthopaedic departments, and accident services was recommended. An Accident Hospital was planned for Birmingham. Hey Groves, in one of his last endeavours, urged the claims of a great accident centre for London. There was progress—but it was slow—very slow.

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The new Journal of Bone and Joint Surgery is a symbol—a symbol of united effort by the nations of the world. In these circumstances we are proud to publish in the first British number a message from the King. His Majesty was anxious “not to let the appearance of this Journal pass without some mark of his approval.” Surgeons throughout the Commonwealth and Empire will accept with devoted loyalty His Majesty’s command to work in collaboration for the welfare of mankind. They rejoice that in this task it is their privilege to join with surgeons of the United States of America.

### LOB’S WOOD

In the midsummer of 1947, fellows and associates of the British Orthopaedic Association sent a warm invitation to their colleagues in the United States to discuss the Journal of Bone and Joint Surgery. The American Orthopaedic Association and the Academy of Orthopaedic Surgeons were prompt in their response. Transatlantic air reservations were made within a few days. Dr R. I. Harris of Toronto travelled, not as the new leader of Canadian orthopaedic surgery, but as President-elect of the American Orthopaedic Association—a Canadian, with British traditions, thinking and speaking as an American—thus linking the Old World with the New. Dr William Rogers, Editor in Boston, came with all the benign and lovable qualities we respect and esteem. Dr Clay Ray Murray of New York—that gallant gentleman—laid aside personal problems and accepted the last duty of his life. Dr Earl McBride of Oklahoma represented, with accomplished charm but firmness of purpose, the younger orthopaedic surgeons and the Academy. Discussions were destined to take place in the President’s room of the Royal College of Surgeons of England with its dignified atmosphere of history and tradition.

Surely it was by more than coincidence that the first week-end was spent resting in that very House-in-the-Wood in Surrey in which J. M. Barrie was for so long a welcome guest, and in which he was inspired to the whimsical writing of “Dear Brutus”—A Comedy in Three Acts. The words of Lob will be remembered: “It is all nonsense of course, just foolish talk of the villagers. They say that on Midsummer Eve there is a strange wood in this part of the country. They say that in the wood you get what nearly everybody here is longing for—a second chance.” British orthopaedic surgeons, young and old, who came to hold preliminary conversations with their American friends will remember that it *was* midsummer, we *were* “in the depths of the wood in the enchantment of a moonlight night,” and we *were* given “our second chance.” What will be our reaction? Will it be that of Margaret “I don’t want to be a might-have-been”? Will it be that of Purdie “I feel there is something in me that will make me go on being the same however many chances I get”? Or will it be that of Joanna, on being reminded of Shakespeare’s words “The fault, dear Brutus, is not in our stars but in ourselves, that we are underlings”?—

“Meaning that we have the power to shape ourselves?”

“We have the power right enough.”

“But isn’t that rather splendid?”

“For those who have the grit in them—Yes.”

### BRITISH-AMERICAN AGREEMENT AND COMMONWEALTH CO-OPERATION

In this number is recorded the agreement reached at the London Conference, held in the Royal College of Surgeons of England in May 1947, between representatives of the British and American Orthopaedic Associations. The agreement was confirmed at the Exeter and Manchester meetings of the British Orthopaedic Association and at the Hot Springs meeting of the American Orthopaedic Association. The new Journal of Bone and Joint Surgery is now established. It will be published every six weeks, four annual numbers being edited and



George Perkins

Earl McBride

William Rogers

Robert I. Harris

Reginald Watson Jones

### LOBS WOOD

We are transplanted to the depths of the wood in the enchantment of a moonlight night *Dear Brutus*—A Comedy in Three Acts—by J. M. Barrie



### ROYAL COLLEGE OF SURGEONS OF ENGLAND

Where formal agreement was reached between the Commonwealth of British Nations and the United States of America. A suite of rooms within the precincts of the College is now the home of the British Editorial Office.

published in Boston, each alternating with one of four numbers edited and published in London. The new Journal is directed by an Editorial Board of thirty-two members—sixteen representing the American Orthopaedic Association and Academy of Orthopaedic Surgeons, and sixteen representing the British, Canadian, and Australian Orthopaedic Associations, the orthopaedic surgeons group of the Union of South Africa, and the orthopaedic surgeons of other Dominions and Colonies of the Empire.

We have embarked upon a venture which is unique in the history of surgical publication. Never have the Nations of the British Commonwealth shared equally in such a project, never have the British nations shared in equal partnership with the United States of America. The task has been accepted with enthusiasm. In the United Kingdom there is an eager sense of adventure and a determination to succeed. In Canada the decision to collaborate was unanimous. The Australian Orthopaedic Association was unanimous in its resolution by which the new arrangements "were heartily endorsed." In New Zealand and the Union of South Africa the agreement was applauded. The development is watched with interest throughout the world.

#### THE AMERICAN ORTHOPAEDIC ASSOCIATION—A TRIBUTE

We in Britain are unwilling to allow the first British number of this Journal to be published without expressing to members of the American Orthopaedic Association our sincere and deep gratitude for the very characteristic generosity with which this great venture has been made possible. The Journal is their property, of which they are justly proud, it has been "their child, created and nurtured by the ideals and efforts and money of their members." They have offered it—freely offered it—to the English-speaking world. It is true that the "child" has now reached adolescence and that it is looking forward to manhood. Its future is even greater than that which was envisaged by its forbears nearly half a century ago. But for the diligence with which growth has been fostered throughout these decades, for the friendly hospitality which has long been offered to the British Orthopaedic Association, and for the wisdom, vision, and foresight with which this new plan has been welcomed, we are profoundly grateful.

#### RECURRENT DISLOCATION OF THE SHOULDER

The merit of international co-operation in clinical and scientific investigation is demonstrated in this number in so far as the problem of recurrent dislocation of the shoulder is considered by a team of Canadian surgeons directed by GALLIE and LE MESURIER, a team of Royal Air Force surgeons whose work has been studied by J. Crawford ADAMS, a group of Scandinavian surgeons who are welcomed to these pages through their spokesman Ivar PALMER, and a number of British surgeons including Blundell BANKART who contributed to a symposium at the Annual Meeting of the British Orthopaedic Association. We regret only that it has not been possible to add contributions from the Johannesburg school, and from KING of Melbourne and MEEHAN of Brisbane, who have done much to solve the problems of this disability. As it is, we are able to report the clinical features, operative findings, and detailed follow-up results in no less than 641 recurrent anterior dislocations of the shoulder—a record in surgical literature.

When many of us were young we were bewildered by the technique of more than sixty operations. We were taught how to transplant a slip of the deltoid muscle, how to lengthen the subscapularis, and how to shorten it, how to plicate the capsule of the joint, to resect it, overlap it, and reinforce it with fascia, how to divide the shoulder muscles with the object of regaining equilibrium, how to osteotomise the coracoid process, lengthen it, and insert grafts into it, how to sling the head of the humerus to the acromion, insert fascial strips, and transplant free tendons, how to graft bone to the neck of the scapula, how to convert the

biceps tendon into an intra-articular ligament, and even how to treat recurrent dislocation by the bone-setter's manipulation. No single structure in or around the joint was immune from attack. We were expected to know the operations of Clairmont, Joseph, Ehrlich, Oudind, Habinette, Rich, Eden, Bankart, Loeffler, Hoffmann, Mandle, Keller, Thomas, Wulffing, Henderson, Kellogg, Speed, Levic, Mialelet, Heymanowitsch, and Nicola. Even within the last ten years new modifications of technique have been described by Wahl, Hobart, Roberts, Kjell-Bergman, Rupp, Fiejka, Kapel, Janek, Ahlberg, Stenport, and Cunitz—and it is with some diffidence that in this very number we record the special technique of the great surgeons Gillie, Putti, and Platt.

Such history indicates that we have indeed lived during the last twenty-five years “in the stimulus of a great period of operative orthopedic surgery” and that such stimulus, by concentrating the minds of surgeons upon technique, has carried with it the danger of neglecting fundamentals. The fact is that the pathological anatomy of recurrent dislocation of the shoulder joint was described very accurately more than sixty years ago. Even before 1890, BROCA and HARTMANN illustrated detachment of the glenoid labrum and capsule with stripping of periosteum from the front of the neck of the scapula, and a traumatic defect in the head of the humerus which allowed it to subluxate over the glenoid margin while still remaining within the capsule of the joint. But these essential pathological features were overlooked and forgotten, and in the course of a feverish search for new modifications of operative technique they were ignored. The attitude of many surgeons is illustrated by the most recently published review on the subject,<sup>1</sup> in which the reviewer suggests that the pathology is really unimportant and indeed “is irrelevant if Nicola’s operation or one of its modifications are used, since this procedure does not aim to repair the anatomical defect.” In the words of EVARTS Ambrose Graham: “There is over-emphasis on the art of surgery. There is neglect of the science of surgery. A man cannot be a good surgeon if he is not a good pathologist. What can we do to reinspire the spirit of John Hunter?”

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\* International Abstracts of Surgery (Surgery, Gynaecology, and Obstetrics (1947)) 85, 391

controlled, 3 The larger the defect in the head of the humerus the more important is the control of external rotation movement

If such principles are accepted it matters not whether the front of the joint is buttressed by capsular suture or fascial repair, by glenoid bone block or coracoid lengthening. It matters not whether external rotation movement is controlled by capsular reefing or subscapular shortening, or indeed by simple immobilisation of the limb in internal rotation after an anterior exposure which is "sufficiently traumatic and sufficiently bloody"—a principle of treatment advocated for recurrent shoulder dislocation two thousand years ago by Hippocrates who used the white hot cautery and insisted that "then above all should the arm be continually bound to the side both night and day, for so would the cavity into which the humerus is mostly displaced be best cicatrised up and cut off." Certainly it matters not whose name is attached to the particular procedure. But although we may agree that individuality should be preserved to the extent that each surgeon will decide for himself whether to use simple suture, fascial transplant, metal staples, or bone grafts, let us also agree that operations will be based upon pathological findings, and that we will not perpetuate biceps tendon transplants, muscle transpositions, acromial slings, and other procedures which are of purely historic interest, which "do not aim to repair the defect," and which have been shown to fail in a lamentably high proportion of cases.

One other feature of shoulder dislocation must be re-examined with the analogy of other joints in mind. We were taught by BANKART that "Recurrent dislocation of the shoulder has nothing whatever to do with ordinary traumatic dislocation. It is from the first an entirely different injury, and it is produced in an entirely different manner. The reason why dislocation recurs after reduction is that whereas a rent in the fibrous capsule heals rapidly and soundly, there is no tendency whatever for the detached glenoid ligament to attach itself to bone." It is unfortunately true that observations made with sufficient emphasis by leaders of the profession are liable to be accepted without further examination, certainly this observation was accepted. Nevertheless it was at least singular that the shoulder, unlike any other joint, should have this distinction between acute and recurrent dislocations. Moreover the belief that in ordinary dislocation of the shoulder there was "a rent in the fibrous capsule" had also been accepted without proof. Every other dislocation was due to avulsion of capsule from bone. There is now increasing evidence (KING,\* GALLIE and EYRE-BROOK this number), that such capsular avulsion represents the pathological anatomy of acute dislocation of the shoulder, and that it is indeed the same lesion which we find in recurrent dislocation. Furthermore Crawford ADAMS shows that recurrent dislocation is not produced "in an entirely different manner." Any type of injury which is known to cause ordinary traumatic dislocation may also cause recurrent dislocation, and the frequency of the different mechanisms of injury is about the same in non-recurrent and recurrent cases, the commonest initial injury in recurrent dislocation of the shoulder is a fall on the outstretched hand. Finally, this writer at least is impressed by the fact that of several hundred acute dislocations treated by complete immobilisation in the position of full internal rotation for not less than four weeks, no case is known to have gone on to recurrent dislocation, whereas every recurrent dislocation he has seen had been treated at the time of initial injury either by no immobilisation at all, or by a form of bandaging to the trunk which did not strictly control rotation movement. We know that acute dislocations of other joints which are not immobilised adequately tend to become recurrent. It is difficult to escape the conclusion that the same may be true of the shoulder, and that increase in the frequency of recurrent dislocation in recent years may be associated with the modern urge for early mobilisation and rehabilitation. Is it possible that many of our operations will become unnecessary when we learn to treat ordinary acute dislocation by rigid immobilisation in the internally rotated position for not less than four weeks?

\* KING THOMAS (1941) Recurrent Dislocation of the Shoulder. The Medical Journal of Australia June 7 1941

# RECURRING DISLOCATION OF THE SHOULDER

W. E. GALLIE AND A. B. LE MESURIER, TORONTO, CANADA

*Based on a Moynihan Lecture delivered by Professor W. E. Gallie  
at the Royal College of Surgeons of England  
Lincoln's Inn Fields on September 24, 1947*

Twenty-five years ago I had the honor of presenting to fellows and members of this College a report of various uses made of the principle of transplantation of fibrous tissues. In that report it was suggested that, as recurring dislocation of the shoulder seemed to result from some defect in the ligaments, it should be possible to repair the defect either by plicating the supposedly loose ligaments with living sutures of fascia, or by replacing them with new ones. Soon afterwards an opportunity arose to try out this suggestion and from it there developed the method which I wish to discuss to-day. It is most gratifying that in this Moynihan Lecture I am to have the opportunity of reporting once more to the Royal College a further application of the principles I presented in the Hunterian Lecture of 1924.

A Moynihan Lecture would be incomplete without reference to the founder. I had hoped to find that at some period in his distinguished career the great man had said or written something which would indicate that he might have been interested in what we are discussing to-day. I have been unable to find any such reference, and I must content myself with telling you that once, long ago, he came into my operating room while an operation such as I shall describe was going on, and showed great interest in those features of it which to him were novel, and in the anatomical exercise involved. A kindly word of encouragement from the great is a priceless thing to the young.

When Le Mesurier and I first became interested in recurring dislocation of the shoulder we were quite ignorant of the cause, and quite without any original idea of how to prevent it. We did notice, however, in performing the various operations that had been recommended, such as Clairmont's operation, Joseph's operation, and plication of the capsule, that we were never able to see a defect in the ligaments through which the head of the humerus had passed at the first dislocation. It gradually dawned on us, as the result of watching a dislocation produced on the operating table with the capsule exposed, that the head of the humerus did not pass out through a rent in the ligaments in the lower part of the joint, but that it simply slipped over the anterior rim of the glenoid into a cavity, lined with synovial membrane, which had resulted from detachment of the capsule and glenohumeral ligament. This pathological picture has been clearly and forcibly described by Bankart (1923, 1938) who on many occasions opened the joint and observed that the capsule and the glenoid labrum were not attached to the rim of the glenoid, and that the head of the humerus could slip over its smooth anterior rim with the greatest ease. While the study of our cases did not involve opening the joint, except in a few instances in which we wished to confirm Bankart's observation, we did notice that in the great majority we could feel the thick edge of the anterior ligaments quite loose from the anterior lip of the glenoid, and occasionally, by rotating the head of the humerus outward, we could see that nothing covered it but synovial membrane.

Careful study of the method of production of the first dislocation in a large number of our cases (nearly 200) has led to some definite observations.

1 It occurs chiefly in young men. We have seen only nine women in 200 cases. The great majority have been in healthy athletic young men of nineteen or twenty years of age.

2 It is frequently double.



3 It sometimes occurs in brothers, we have three pairs of brothers and two pairs of twins

4 It usually begins as an ordinary traumatic dislocation, quite indistinguishable from the common subcoracoid variety

5 On the other hand it often results from trivial force such as raising the arm overhead to dive, swimming breast stroke, or suddenly reaching upward for a hat. Of 100 cases in which this point is recorded seventeen resulted from some very slight trauma

6 It quite often accompanies epilepsy. Of 135 cases in which comment has been made, there were eight cases of epilepsy. The first and subsequent dislocations usually took place in bed and were almost always double

7 It often occurs as an incomplete dislocation the first time. In 10 per cent of our cases, as the result of some slight exhibition of force in which the head of the humerus is levered forward, or downward and forward, and rotated outward, the head slips up on the anterior rim of the glenoid and then drops back into its normal position. Each time this happens the degree of forward slipping increases until a day comes when the head does not slip back spontaneously. Frequently the patient reduces such dislocations himself by slight manipulation of the arm (usually inward rotation) or he gets a bystander to do the manipulation for him. The amount of pain is slight. Finally the range of forward slipping increases so much that the head passes completely over the anterior brim of the glenoid on to the anterior aspect of the neck of the scapula, and then an anaesthetic may be required for the reduction

8 In most cases of chronic recurring dislocation the amount of forward and inward displacement of the head is small, not more than can be accounted for by displacement of a little more than half the head beyond the rim of the glenoid. Usually the patient is able to reduce the dislocation himself. Often such cases have never been seen by a doctor

9 In such cases the diagnosis can be confirmed by abducting the patient's arm to a right angle, pressing the head of the humerus forward, and levering the elbow backward. The head either dislocates forwards, or rides up on the brim of the glenoid, and gives the patient the sensation of impending dislocation

10 Many patients complain that as a result of abduction and eversion movements of the shoulder they often feel the head slip up on to the anterior brim and then spontaneously, or as the result of protective muscular action, slip back again. Such patients are in constant dread of complete dislocation

A typical history is as follows. A young athletic man, who has never had anything the matter with his shoulder before, is injured in a football game or as the result of a fall in skiing. The mechanism is indistinguishable from that of any traumatic dislocation. Clinical and radiographic examination show an ordinary subcoracoid dislocation. Reduction is accomplished under anaesthesia and the arm placed in a sling. Exercises are begun in a week and in the course of two or three weeks the shoulder seems normal. Several months may go by and then suddenly, as the result of some insignificant strain or even as the result of some normal movement in which the arm is abducted and rotated outward and levered backward, the dislocation recurs. As time goes on this happens more and more frequently, until it may happen several times a week and result in chronic invalidism. Many such patients are able to produce and reduce the dislocation at will

#### PATHOLOGY OF RECURRENT DISLOCATION

Just why certain anterior dislocations of the shoulder become recurrent, whereas others do not, cannot be considered settled, for the number of opportunities anyone has had to dissect recent traumatic dislocations is too small to merit generalisations. It may be that the injury to ligaments, whatever it may be, sometimes heals and the joint returns to normal

In recurrent cases, however, the defect is invariably at the anterior brim of the glenoid where the capsule, glenohumeral ligaments, and glenoid labrum, instead of being attached to the brim and neighbouring neck of scapula are permanently detached and separated from it by synovial membrane which pouches out from the joint. Inspection of these cases with the joint open, as Bankart has pointed out, shows that the articular cartilage of the glenoid fossa seems to extend smoothly forward over the brim without the presence of any normal preventive of forward slipping of the head of the humerus such as the wedge of fibro-cartilage which raises the lip, or the ligaments which are attached to it. On the operating table it is possible to slip the head forward over the brim with the greatest ease.

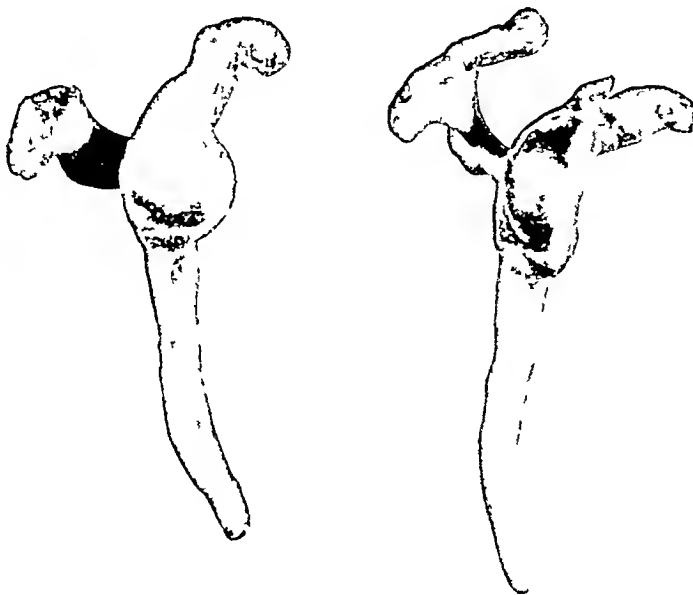


FIG 1

Photographs of dry specimens of scapula showing marked variation in shape of the glenoid fossa. Specimen to the left is normal that to the right is very narrow.

The explanation of this condition seems obvious. When the original dislocation took place the head of the humerus was levered forward until the ligaments and labrum were torn off the rim of the glenoid and the head slipped out. When reduction was made the ligaments and labrum dropped back but for some reason did not heal, or heal strongly, in place. The result is that with some more trivial strain the joint dislocates again or perhaps undergoes a series of incomplete dislocations until the defect in attachment of the anterior ligaments is sufficiently stretched to allow the head to slip out completely. It is probably going too far to say that in every case of anterior dislocation of the shoulder in which the ligaments are torn off the glenoid brim, the defect in the joint fails to heal. Indeed I think it likely that the commonest lesion in ordinary anterior dislocation of the shoulder is this separation of anterior ligaments from the bone, and that in most instances the healing process is sufficient to prevent recurrence of the displacement. All we are sure of is that in recurring dislocation the avulsed anterior ligaments have failed to heal and the stage is set for further dislocation.

We still have to explain the pathology of cases which occur without traumatism, and also the high proportion of cases in which both shoulders are involved, and in which several members of the same family are afflicted. The natural conclusion is that they are the result of a congenital defect, although in the case of double dislocations in epileptics this is probably not so. On several occasions I have seen epileptiform convulsions on the operating table,

once when the shoulder joint had been exposed, and the force driving the head of the humerus forward was symmetrical, and terrific, so that I have no doubt that double dislocations in epileptics are not based on anatomical anomalies but are the result of repeated attacks of violent muscular contraction which are quite sufficient to tear the anterior ligaments from their moorings or to stretch them. In epileptics the dislocations do not appear to be the result of falls but are the result of violent muscular contraction with the arm at the side. This usually occurs when the patient is in bed.

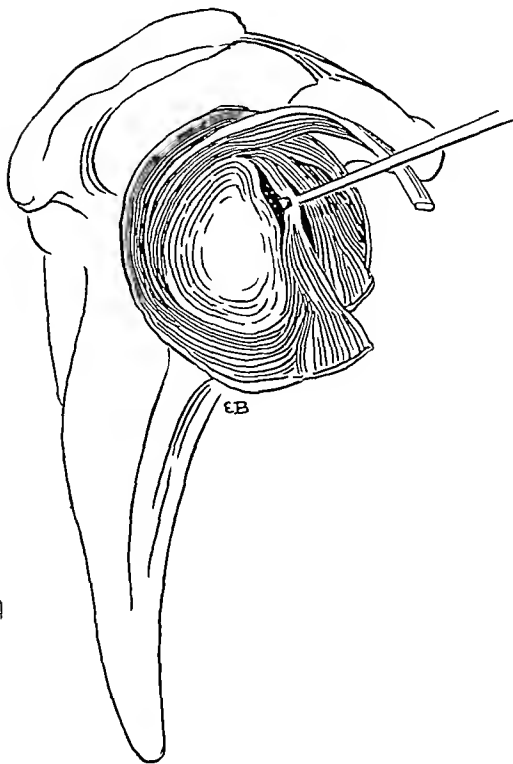


FIG 2

One of several specimens found in the Anatomical Department of the University of Toronto by Professor Grant, showing the upper half of the inferior gleno-humeral ligament and labrum not attached to the glenoid margin. This anomaly may predispose to atraumatic dislocation.

A study of the pre-operative radiographs of patients in whom the first dislocation occurred spontaneously, or as the result of slight trauma, shows some not very impressive abnormalities. Sometimes the head of the humerus looks disproportionately large for the glenoid. Sometimes too the glenoid looks flat, and without any clear cut anterior margin, quite different from the frankly traumatic cases, in many of which the anterior rim of the glenoid can be seen to have been avulsed, or marked by a deposit of calcium salt or new bone laid down on the neck of the scapula where the ligaments are normally attached.

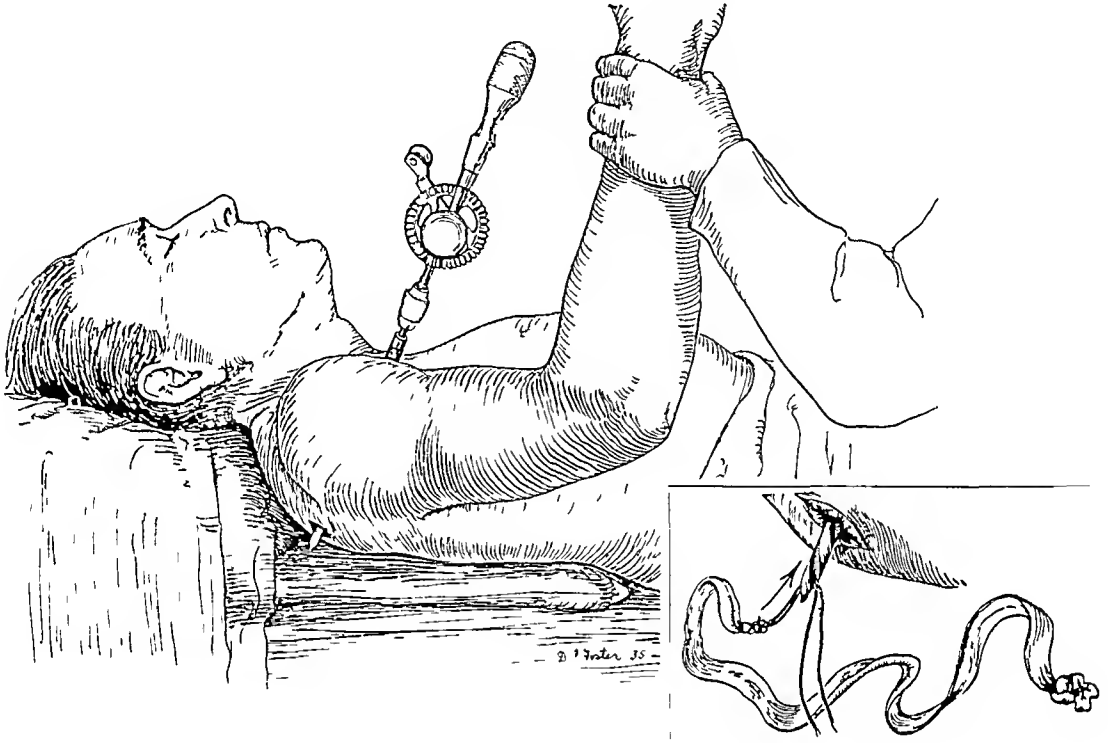
In order to gain definite information on the question of anatomical anomalies Professor J C B Grant has examined the shoulder joints of a large number of cadavers in the Anatomical Department of the University of Toronto and has observed definite variations in the attachment of ligaments and the labrum. Normally the labrum is firmly attached to the marginal eighth of an inch of the glenoid fossa. To its external edge are attached some fibres of the capsular ligament and particularly the inferior glenohumeral ligament as it passes to its

scapular attachment. Indeed the anterior portion of the labrum may be considered part of the inferior glenohumeral ligament. It will be readily appreciated, therefore, that any force which tends to avulse the capsule from the anterior aspect of the neck of the scapula will also carry the glenoidal labrum with it. Professor Grant has observed that sometimes the labrum is not attached to bone throughout, but only at intervals, and that a hook can be slipped under it, thus lifting it from the bone (Fig 2). It may be that anomalies of this type account for the ease with which the head of the humerus sometimes slips over the glenoid rim. At any rate nothing but a congenital defect can account for double dislocation occurring without trauma, and for single and double dislocations occurring in families. (We have two pairs of twins with atraumatic double dislocations and three pairs of brothers.)

#### TREATMENT BY FASCIAL REPAIR OF THE DETACHED LABRUM

Aside from whether the tendency to redislocation is the result of congenital defect or traumatism, the cause of recurrence is the same, namely, loss of the normal obstruction to forward displacement of the head. The indications for treatment, therefore, are clear—the

repair of damaged ligaments or the construction of new ones. Unfortunately the anterior rim of the glenoid, and the anterior aspect of the neck of the scapula, are so remote that technical procedures are difficult and can be trusted only to surgeons who are willing to study the anatomy. It is obvious that in order to fasten avulsed ligaments or any new ligaments to the anterior border of the glenoid one must either do an extensive reflection of the muscles which lie on the front of the shoulder joint, or devise some completely new way of



FIGS 3-4

The drill passes through the shoulder and projects through a short incision below the spine of the scapula. A strip of fascia lata knotted at one end is attached to the drill at the other and pulled through the head of the scapula until the knot comes to rest against bone.

fastening the ligaments down. It was puzzling over this problem, both in the operating room and in the anatomical laboratory, which led to the method I shall now describe. A preliminary report of four cases was made in 1927.

**Details of the operation**—A slightly oblique incision is made, about five inches long, from just above the tip of the coracoid process downward and outward along the anterior border of the deltoid muscle. The cephalic vein is located, the deltoid and pectoralis major muscles are separated, beginning above the tip of the coracoid, and the pectoralis major and cephalic vein are drawn inwards. The short head of the biceps and the coracobrachialis are then separated from the capsule of the shoulder and neck of the humerus, and retracted inwards. This exposes the tendon of insertion of the subscapularis, the quadrilateral space, and three anterior circumflex veins lying parallel to and just below the lower border of the subscapularis. These veins are constant and form a good landmark for the subscapularis. They should be protected from injury because if torn they retract and bleed copiously.

The loose areolar tissue along the lower border of the subscapularis is then opened by blunt dissection and the white capsular ligament of the shoulder, as it lies on the front of the glenoid, comes into view. With the biceps and coracobrachialis retracted inward and the subscapularis upward the anterior lip of the glenoid is then palpated through the capsular ligament, and one can often feel that this ligament and the labrum are detached from the bone and separated from it by a pouch of synovial membrane. At this stage

one may dislocate the head of the humerus forward and see it slip over the anterior lip of the glenoid. Occasionally by rotating the humerus outward one can see that the head is covered only by a thin synovial membrane.

With the forefinger of the left hand on the anterior brim of the glenoid a point is

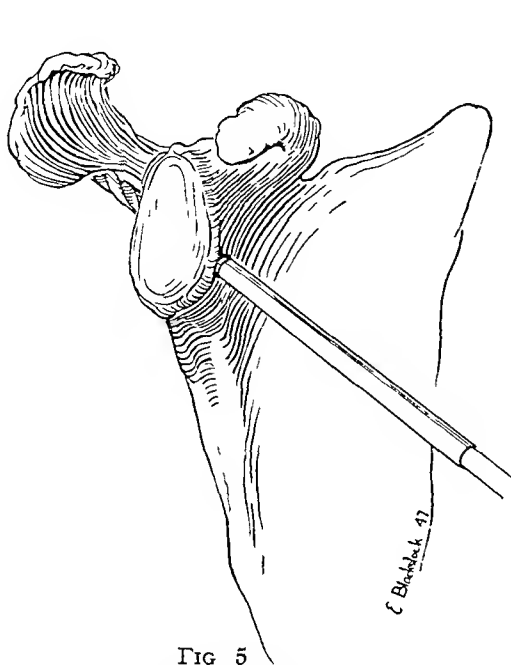


FIG 5

A hole is drilled through the head of the scapula

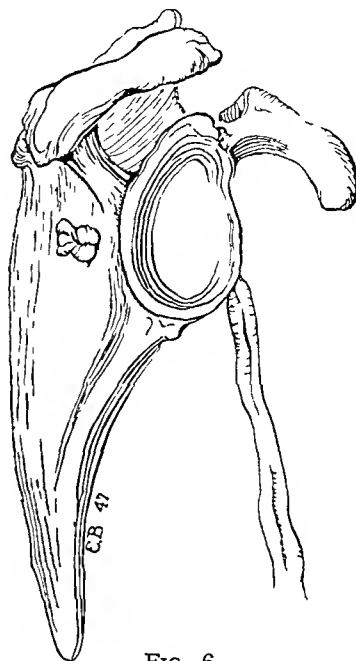


FIG 6

The new ligament is anchored in the scapula

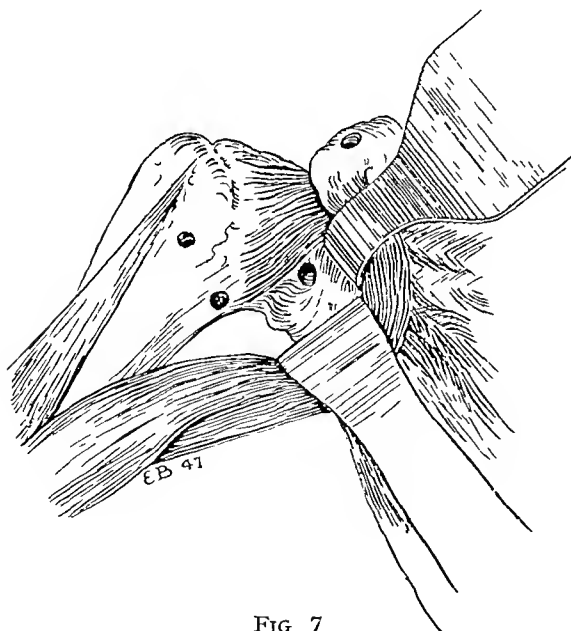


FIG 7

Showing the position of the drill holes for the new ligament

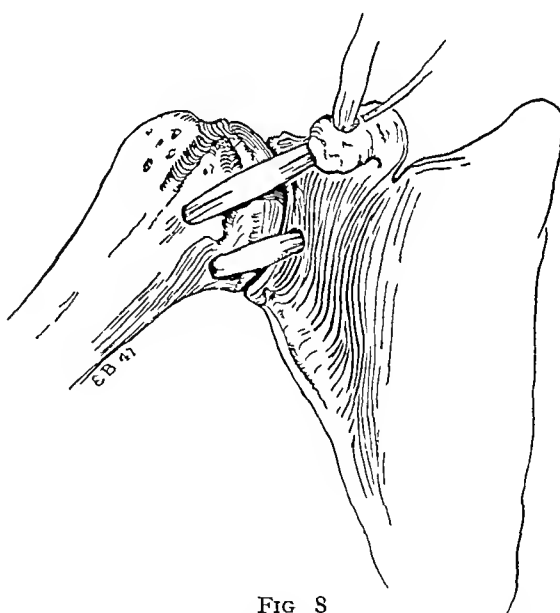


FIG 8

The new ligament has been drawn through the head of the scapula, humerus, and tip of the coracoid. It is ready for tying.

selected about half an inch above its lower border, and the point of a long three-sixteenth inch drill is pushed through the detached ligaments and tapped into the subjacent bone. The drill is pointed backward, upward, and slightly outward, aiming at a point just below the outer part of the spine of the scapula. It is then driven through the head of the scapula and after it penetrates the bone it is tapped steadily onward until it reaches the skin just below the scapular spine. A half-inch incision allows exposure of the point of the drill.

A strip of fascia, one inch wide and ten inches long, is then removed from the thigh. In one end a single knot is tied and carefully oversewn with fine silk or catgut to prevent untying. To the other end is attached a stout silk ligature which is passed through the eye of the drill sticking out of the patient's back. A long artery forceps is then passed into the incision in the back, along the drill, as far as the bone, and opened up and withdrawn so as to enlarge the opening through the muscle and fascia sufficiently to allow the knot in the end of the strip of fascia to pass. The drill is then withdrawn and when the heavy silk and the fascia appear in the anterior wound they are grasped and pulled firmly until the knot impinges against the back of the neck of the scapula. This is the whole point of the operation. We now have the new ligament solidly attached to the scapula. It will be observed that it has been accomplished without cutting anything but the skin.

A modification of the above technique may or may not be of advantage. Before pulling the fascia through the neck of the scapula it is split longitudinally into two strips, one of which is about one-quarter inch wide. After pulling the fascia through the scapula the narrow strip is threaded on a fascia needle and passed through the capsular ligament or the labrum. The two strips are then tied together and the knot oversewn. The result is that the capsule is fastened down to the neck of the scapula and may help in preventing dislocation.

In either case the operation is completed by passing the fascia through a tunnel in the head of the humerus and a hole in the tip of the coracoid. The new ligament is terminated there by splitting it, pulling one tail through the tendon of the biceps and tying it to the other tail. It is drawn sufficiently taut to limit external rotation of the shoulder about 25 degrees. Ultimately this limitation nearly disappears.

As nothing has been cut, closure of the wound requires only skin sutures. A binder holds the arm at the side. The patient is kept in bed for eight or nine days to allow the rent in the fascia lata to heal and is then allowed up with his arm in a sling. He should not abduct or externally rotate the arm for a month. He then begins to exercise the arm and move the shoulder. At first there is marked limitation of abduction and external rotation but in the course of three or four weeks this disappears and nothing is left except slight limitation of external rotation. He uses the arm normally.

#### RESULTS OF TREATMENT BY FASCIAL REPAIR

The first operation in this series was performed in 1926 and since then 175 operations have been performed by myself and my colleagues. Careful notes and follow-up records have been maintained. There were no deaths and no infected wounds. All returned to their ordinary work, and the eighty which occurred in the Armed Forces were returned to duty.



FIG 9

Radiograph two years after operation showing correct position of drill-holes in scapula and humerus

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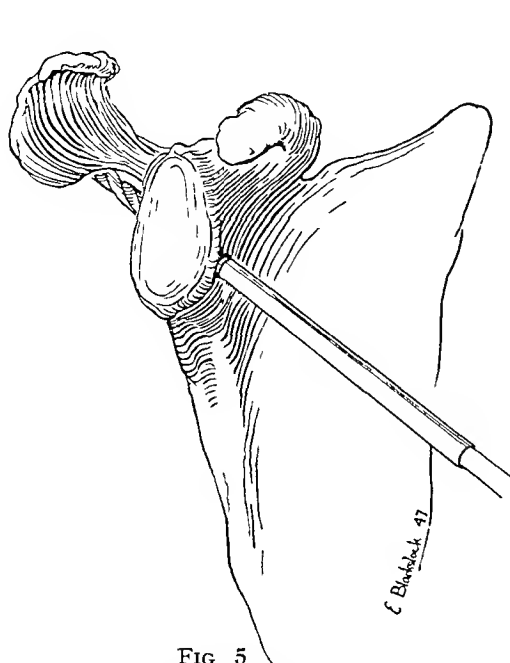


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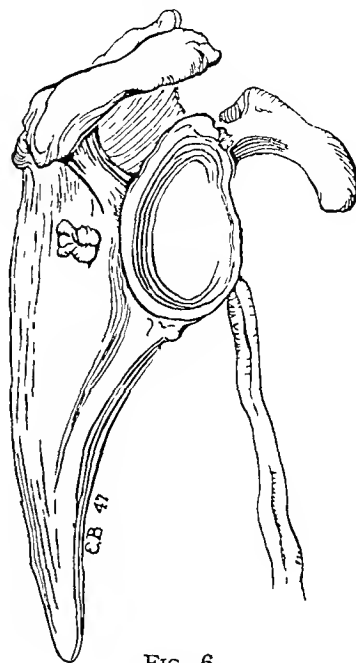


FIG 6

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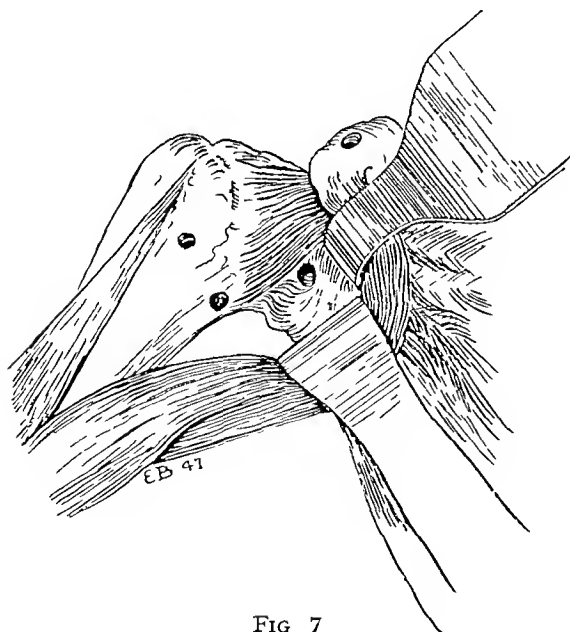


FIG 7

Showing the position of the drill holes for the new ligament

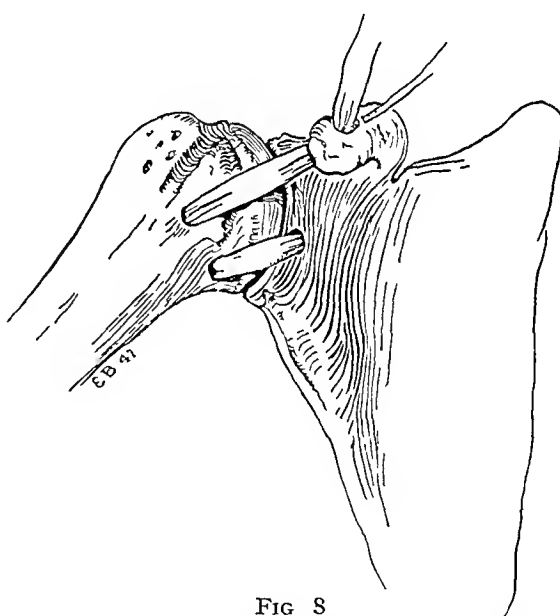


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and ultimately demobilised without pensionable disability. The patients are not conscious of any disability, but on careful examination it will be found that with the elbow at the side and flexed there is a slight limitation of external rotation.

There have been seven recurrences and fortunately we have had an opportunity to study them fully.



FIG 10

Drill hole too low in the glenoid lip. Also note lack of prominence of the anterior lip, often observed when the first dislocation was due to very slight injury.



FIG 11

Improper position of drill-hole in the scapula. The new ligament does not prevent forward dislocation. A Nicola operation had been done previously.

#### Case 1 M V, aged 28 years

On August 9, 1929 he sustained an ordinary subcoracoid dislocation. He then developed recurrent dislocation and when I saw him on July 29 1930 the shoulder was dislocating into the subcoracoid position several times a day. He was able to dislocate the joint at will. The operation described above was done a few days later and he made a complete recovery. I heard nothing more of him for nine years. Then on June 5 1939 he was brought into hospital with a subcoracoid dislocation which had resulted from a fall from a height in which he landed on the back of his shoulder on a steel girder. It was a terrific injury. This dislocation was reduced under anaesthesia and he made a good recovery. He has had no trouble with this shoulder since that time. From this account it is evident that whatever injury to the ligaments resulted from the fall there must have been sufficient healing to prevent further dislocation.

#### Case 2 J T, aged 23 years

Recurring dislocation from ten years of age without any history of injury. Operation performed August 11, 1944, as described above. All well till June 21, 1945 when he fell from the top of an aeroplane, fifteen feet, and saved himself by grabbing a spar. As a result his whole weight of 200 pounds came on his arm which was yanked above his head and the shoulder dislocated. From then on he had recurrences with slight movements so that a further operation was necessary. This was done on August 21 1945. The dissection showed that the new ligament had been torn out of the scapula and that conditions were as before the first operation. A new ligament was inserted with the modification that a strip of it was used to tie the ligaments and labrum to the rim of the glenoid. He has had no trouble since.

#### Cases 3-7 Five cases in which

the point of attachment of the new ligament was so low that the head of the humerus could slip forward above

it These operations were performed when we thought the dislocation occurred chiefly downward and forward and before we realised that the displacement is forward Four of these cases were operated upon a second time, in each the new ligament was located and it was demonstrated on the operating room table that the head of the humerus slid forward above it New ligaments were then inserted at a higher level and there has been no further trouble

Of these seven recurrences, therefore, two were the result of very severe violence that would probably have dislocated a normal shoulder One of these has remained cured for eight years without further operation The other has apparently been cured by further operation

The other five recurrences must be attributed to a technical defect in the operation and should not appear again If the new ligament is attached to the neck of the scapula a little below the middle of the anterior edge of the glenoid the head of the humerus cannot slip forward

#### THE PERMANENCE OF NEW LIGAMENTS MADE OF FASCIA

Experimental studies and clinical experience have shown that fascia lata when transplanted from one place to another in the same animal will continue to live, practically



FIG 12

Ligament made of fascia lata inserted six years before It is thick and strong circular in cross-section and covered with a smooth acrolar sheath It is held to view on a pair of dissecting forceps The white cylindrical structure to its left is the tendon of the long head of the biceps

unchanged These cases in which we were obliged to operate a second time have given us an opportunity to examine such fascial transplants Fig 12 is a photograph made in the operating room at one of these second operations and shows a fascial ligament which had been inserted six years before Except that it is now folded into a rounded cord, it is much as it was the day it was inserted, and microscopical examination confirms this (Fig 13)

During the past twenty-five years many other methods of treatment for recurring dislocation of the shoulder have been devised and I am sure that some of them are highly successful. We have not used them to any great extent because we have been interested chiefly in the principle of the transplantation of fibrous tissues and the use of such transplants in repairing the actual defect. The operation described is safe, as indicated by the absence of mortality and infection and by the quick return of normal function. It is reasonably simple, involving no cutting of important structures and no risk of injury to great vessels or nerves. It is highly successful as witnessed by the recurrence rate of seven in 175

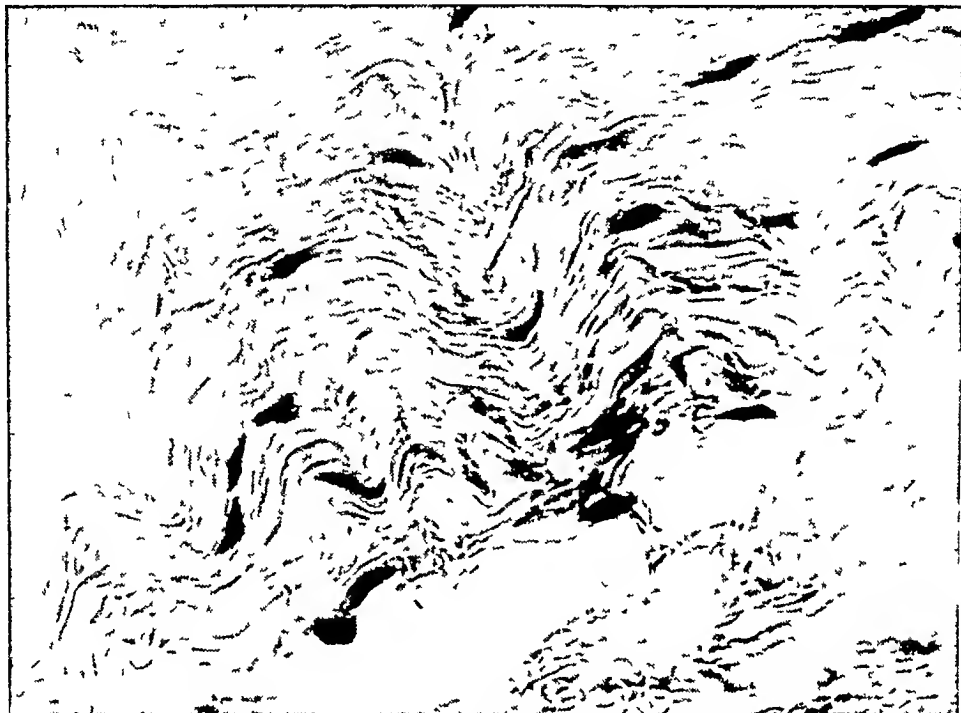


FIG 13

Longitudinal section (high power) of the ligament shown in Fig 12 which was recovered six years after operation. It seems to be normal fascia lata.

operations. Among the patients have been professional football and hockey players, champion ski jumpers, wrestlers, boxers, ordinary day labourers, and many members of the Armed Forces. To any surgeon who is interested in an unusual anatomical exercise, this operation is therefore recommended with confidence.

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# HABITUAL DISLOCATION OF THE SHOULDER

## The Putti-Platt Operation

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*Paper read in opening a Symposium at the Annual Meeting of the  
British Orthopaedic Association, October 1947*

Habitual dislocation of the shoulder joint was known to Hippocrates and to Paul of Aegina. The illustration of Broca and Hartmann, taken from *Bulletins of the Anatomical Society of Paris* of 1890, illustrates how comprehensive was the knowledge of gleno-labial detachments and deformation of the humeral head more than sixty years ago (Fig 1). Little has since been added to this knowledge, though it has been reviewed in masterly style by Tavernier (1929) and more recently by Eyre-Brook (1942). Bankart (1923) re-emphasised the importance of the labial detachment and advocated for the first time an operation for its reattachment to the bone margin of the glenoid. This operation became the standard

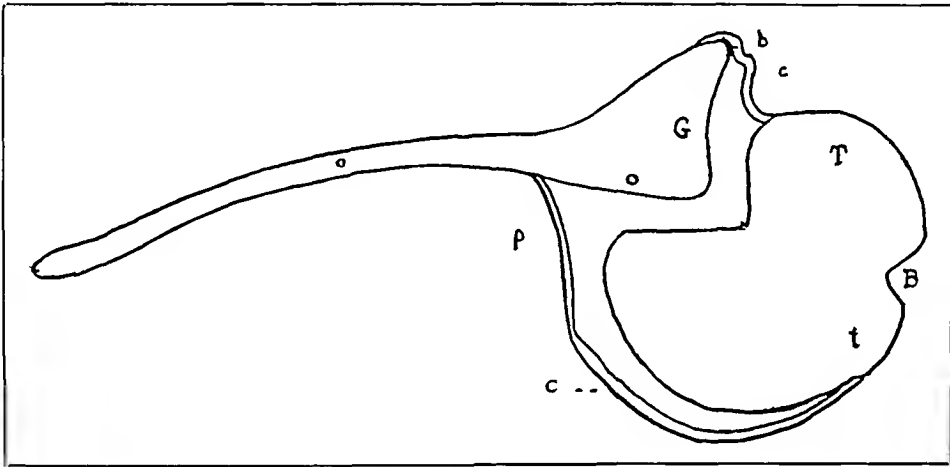


FIG 1

Broca and Hartmann's illustration (1890) of horizontal section through shoulder showing forward dislocation, detachment of labrum and periosteum of neck of scapula, and the anterior margin of the glenoid engaged in the posterior defect of the head of the humerus. G—glenoid, o—neck and body of scapula, p—periosteum, c—capsule, t—lesser tuberosity, B—bicipital groove, T—greater tuberosity, b—posterior attachment of labrum.

British practice for the next ten years, until the Nicola procedure seemed to offer a method of less technical difficulty. During these ten years, however, some surgeons realised that there is not *always* a gross lesion of the gleno-labial margin. As Platt says in a personal communication: "I evolved my present technique after the first few experiences of carrying out the Bankart procedure as described by him originally. I soon found there was no single and constant 'Bankartian' lesion capable of being repaired by a standard procedure. It therefore occurred to me to make sure by stitching the distal end of the divided subscapularis tendon to the cartilaginous remains of the glenoid margin. This provided a primary barrier to redislocation of the head forwards and inwards under the subscapularis. It then appeared logical to stitch the proximal divided end of the subscapularis to the anterior capsule—thus producing an overlap and shortening of the tendon." This was the genesis of the operation which I have called the Putti-Platt capsulorrhaphy. The first operation was performed at Ancoats Hospital, Manchester, by Platt on November 13, 1925.

Some years later I saw Putti performing the same type of operation which had been his standard practice since 1923, being described by his pupil Valtancoli in 1925 and more

comprehensively by Boicev in 1938. Personal inquiries within the past few months from Scaglietti, another of Putti's pupils, reveal that the operation may well have been performed first by Codivilla, Putti's teacher and predecessor, who like Platt never described it in the literature. Since Putti certainly performed it, and since Platt certainly thought out and performed the procedure independently, it seemed to me justifiable to link their names as an eponymous title for the operation. For the sake of euphony, rather than to indicate precedence, the combination "Putti-Platt" was adopted. A substantially similar but more complex procedure has been described by the Swiss surgeon Matti (1936).

### OPERATIVE DETAILS

Four layers are divided to reach the shoulder—the skin, the delto-pectoral muscle layer, the coraco-brachialis layer, and the subscapularis-capsular layer. An anterior approach is used, the skin wound curving inwards along the outer one-third of the clavicle and then extending downwards for about six inches. It is important that the incision should skirt the medial edge of the tip of the coracoid process. The groove between the deltoid and pectoralis major muscle is widely opened (Fig 2). This is made easier, and less retraction is required, if the clavicular portion of the deltoid muscle is almost completely divided three-eighths of an inch distal to the bone; subsequent resuture is much easier if division is made through the muscle than if the muscle is detached subperiosteally. In opening the delto-pectoral groove the cephalic vein is usually ligated. Several small but troublesome vessels in the subacromial region cross the upper limit of the delto-pectoral groove and are worth while identifying and tying.

The next step is to expose the coracoid process and free the conjoint tendon of the coraco-brachialis and short head of the biceps. To do this adequately it is wise to divide the upper inch of the margin of the pectoralis major tendon, and particularly the attenuated expansion of it which runs upwards under the deltoid to reach the capsule of the joint, and which gives the appearance of thickened deep fascia. The interval between the conjoint tendon and the pectoralis minor is opened with care in order to avoid damage to the musculocutaneous nerve, its branches, or the main axillary neuro-vascular bundle which is close by (Fig 3). The tendon is freed on all aspects and divided close to the coracoid process, leaving a sufficient stump to facilitate subsequent repair. I find this to be more simple than the Morestin-Bazy technique of division and repair of the coracoid process. The conjoint tendon is retracted downwards by a stitch, but to avoid damage to its nerve supply it should not be freed too extensively along its medial border, nor pulled on too vigorously.

The next step is to divide the tendon of the subscapularis muscle. Its upper and lower margins are readily identified by rotating the arm outwards. The lower margin is conspicuous because three veins which accompany the anterior humeral circumflex artery run below it (Fig 4). These vessels are divided between artery forceps and ligated. A blunt spike is passed beneath the tendon from above or below, and the tendon is divided one inch from its insertion. In this step the capsule, which is usually adherent to the deep surface of the tendon near its insertion, is frequently opened (Fig 5). The subscapularis is retracted medially by three or four stitches inserted through it.

If the capsule has not already been incised, it is deliberately opened. The glenoid margin and the humeral head are examined for defects. It is common to find a tear of greater or less magnitude in the gleno-labial attachment, a defect in the head of the humerus, and a remarkably voluminous anterior capsule.

**Definitive repair**—The distal stump of the subscapularis tendon is attached to the most convenient soft tissue structure along the anterior rim of the glenoid cavity. Sometimes this is the labrum itself. In other cases, when the capsule and labrum have been stripped not only from the glenoid margin but also from the front of the neck of the scapula, the suture is made to the *deep* surface of the stripped capsule and subscapular muscle (Fig 7).

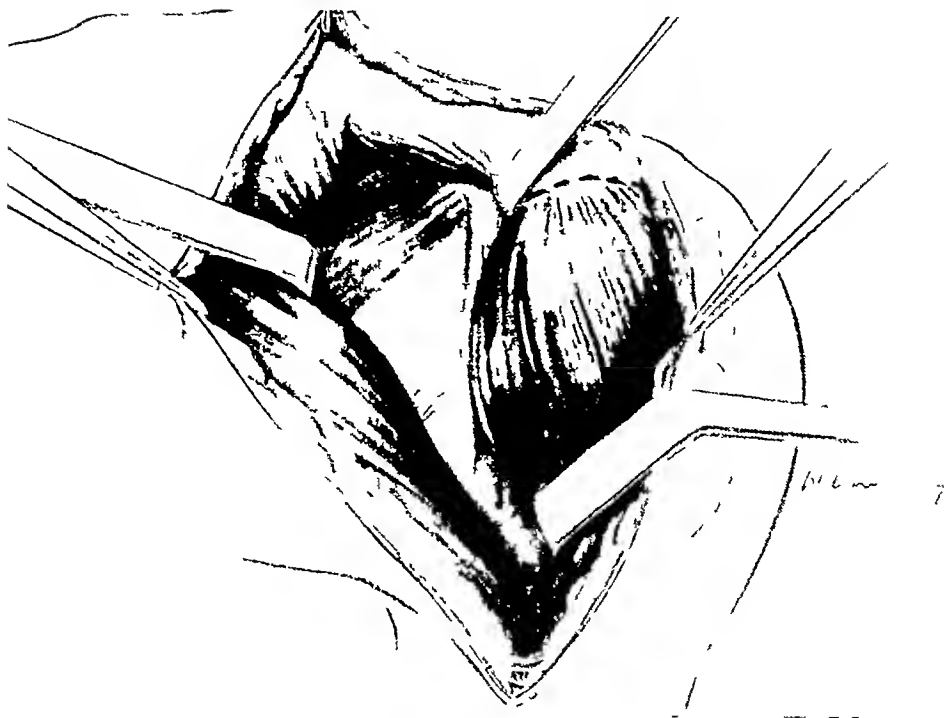


FIG 2

Incision below outer third of clavicle and over delto-pectoral groove exposing the interval between the two muscles which is deepened to show the third layer



FIG 3

Note the axillary neuro-vascular bundle lying deep to the medial aspect of the coraco-brachialis. The lateral cord of the brachial plexus before continuing as the lateral head of the median nerve gives off the musculocutaneous nerve which is liable to be injured by vigorous traction or free mobilisation.

In these circumstances it is advisable to raw the anterior surface of the neck of the scapula so that the sutured tendo-capsule will adhere to it. A small Mayo cutting needle, stout chromic catgut, a powerful needle-holder, and adequate retraction of the humeral head by the suitable manipulations of an assistant, are all the 'special' instruments required. It

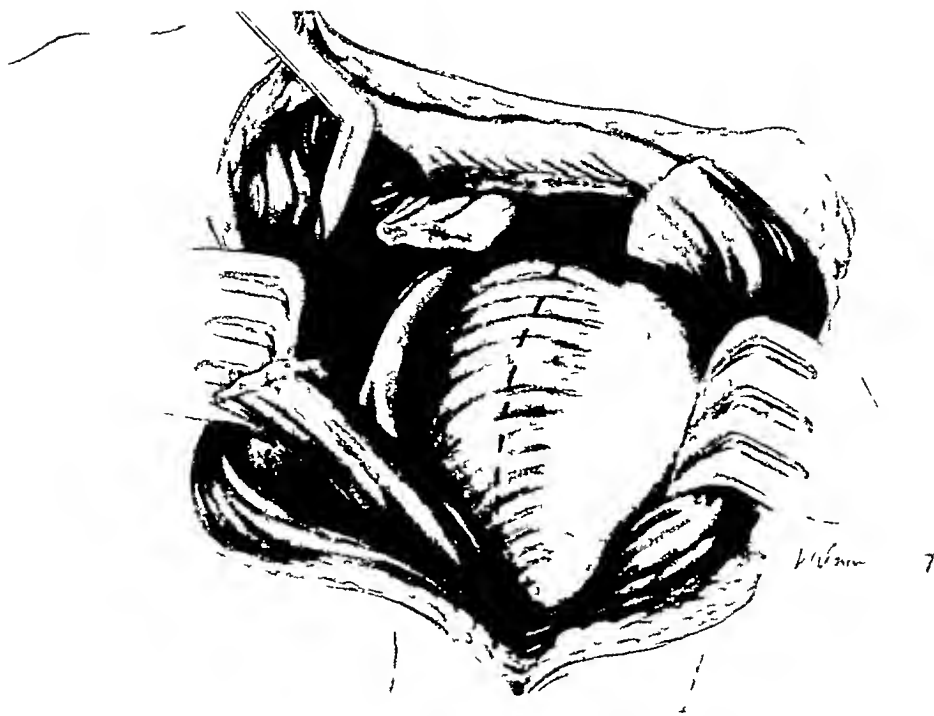


FIG 4

The coraco brachialis has been divided close to the coracoid process and retracted downwards. Note the line of division of the subscapularis.

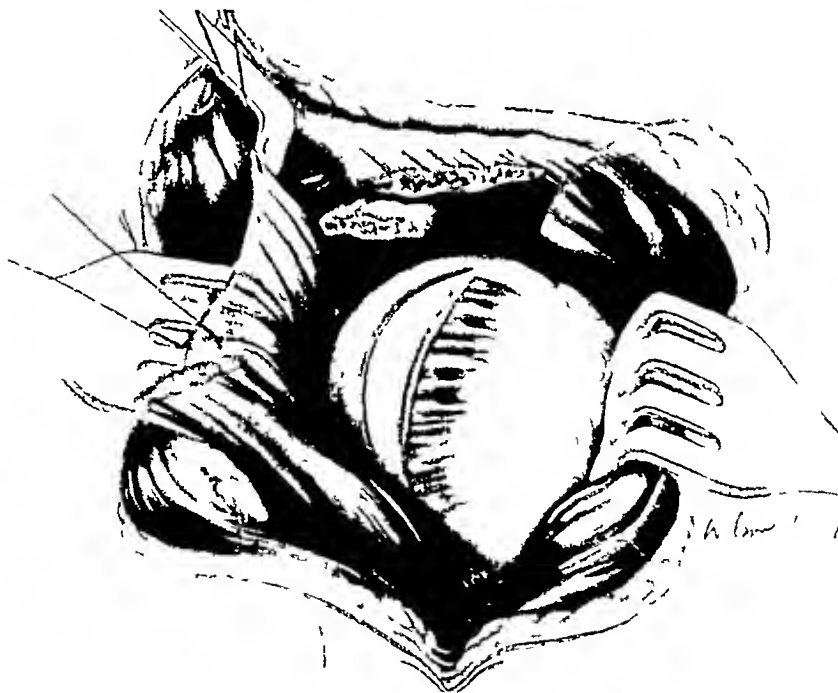


FIG 5

The subscapularis has been divided and the proximal part of the muscle retracted inwards (the lower margin of division being identified by three veins accompanying the anterior humeral circumflex artery which are ligated). The underlying and adherent capsule is incised in the course of muscle division or deliberately opened.

may be awkward to insert the sutures but the embarrassment is no more than time-consuming. There is no risk of causing further damage to the anterior margin of the glenoid or the articular cartilage. Four sutures are inserted and tied while the limb is internally rotated (Fig 8). The medial portion of the capsule is drawn outwards to overlap the tendon.

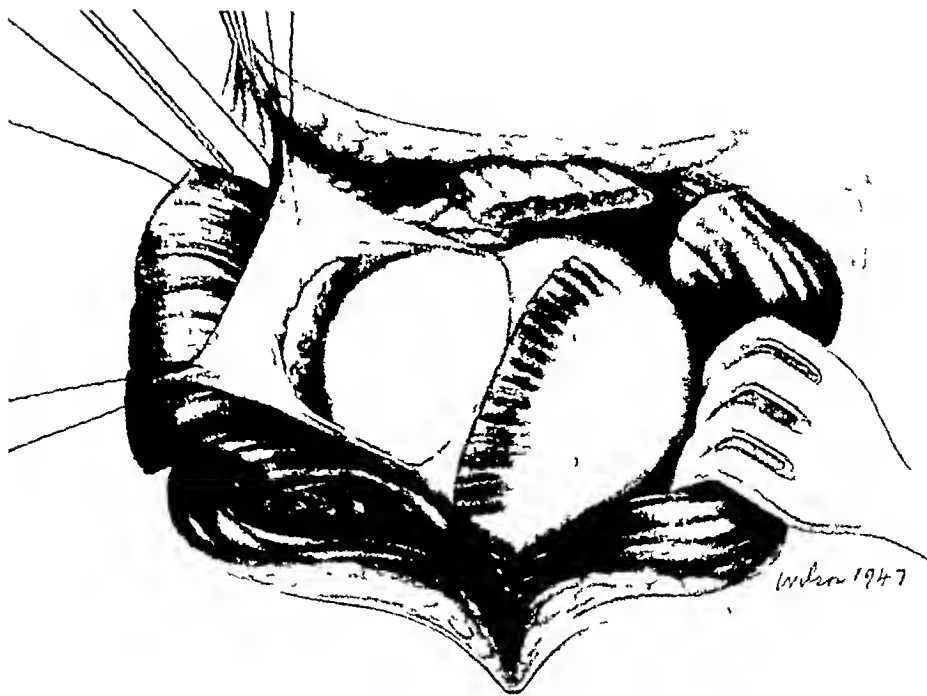


FIG 6

The capsule is retracted inwards and the Bankart lesion exposed. The labrum is torn off the glenoid margin and the capsule stripped from the neck.

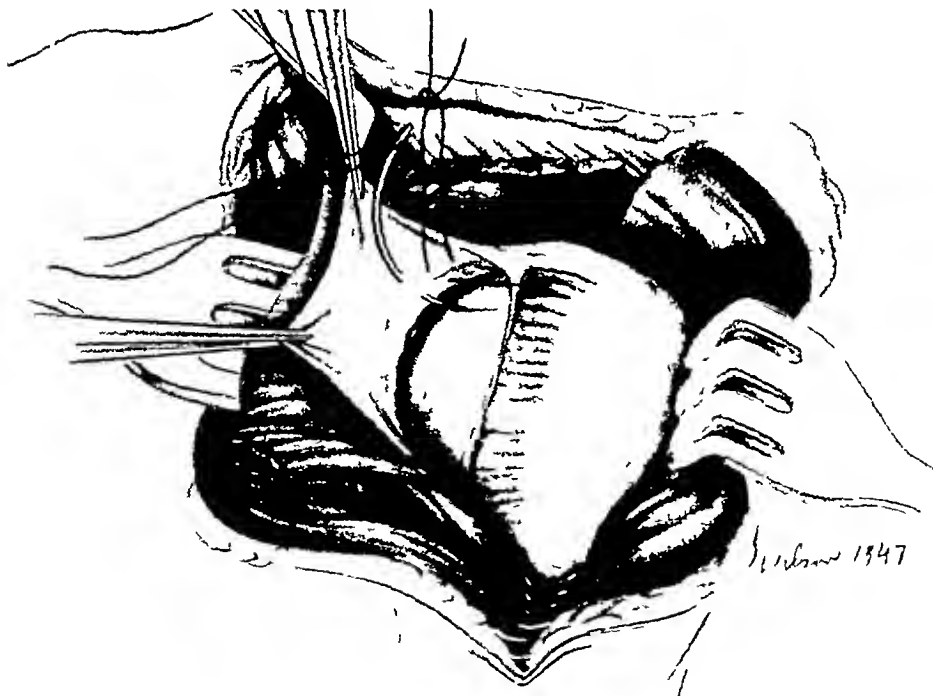


FIG 7

The tissues in front of the neck of the scapula (labrum, periosteum, deep capsule) are stitched to the distal stump of the subscapularis.

of the subscapularis, giving a "double-breast coat" effect. A further overlapping—"an overcoat"—is provided by suturing the muscle belly of the subscapularis to the scarified tendinous cuff which overlies the greater tuberosity, or the bicipital groove (Fig 9). This causes shortening of the subscapularis which, however, must not be overdone. At the end



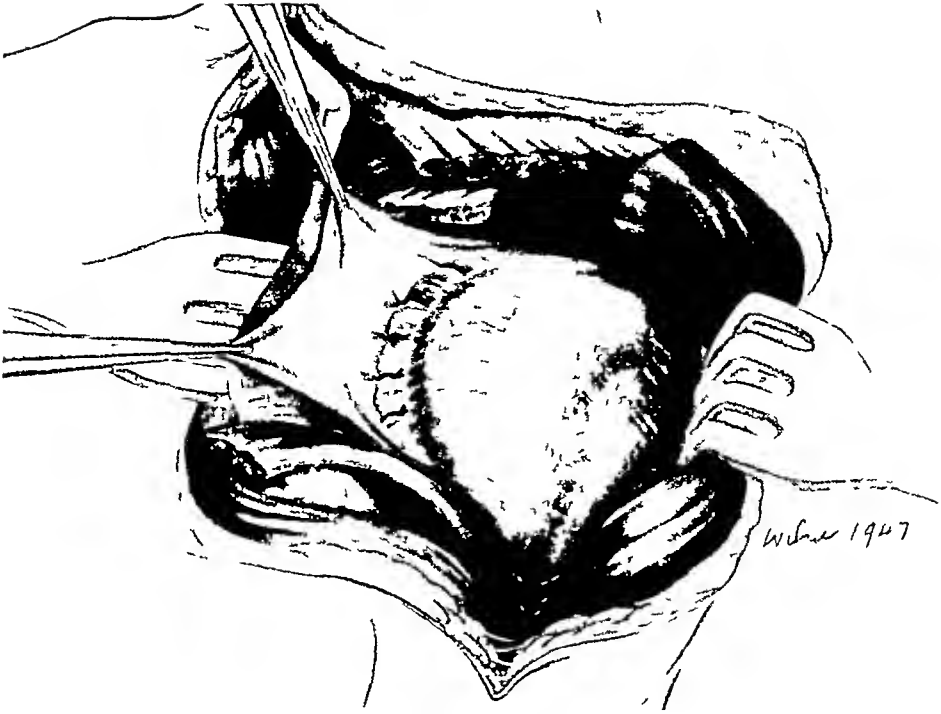


FIG 8

The four or five sutures which have been inserted are tied while the limb is held in internal rotation

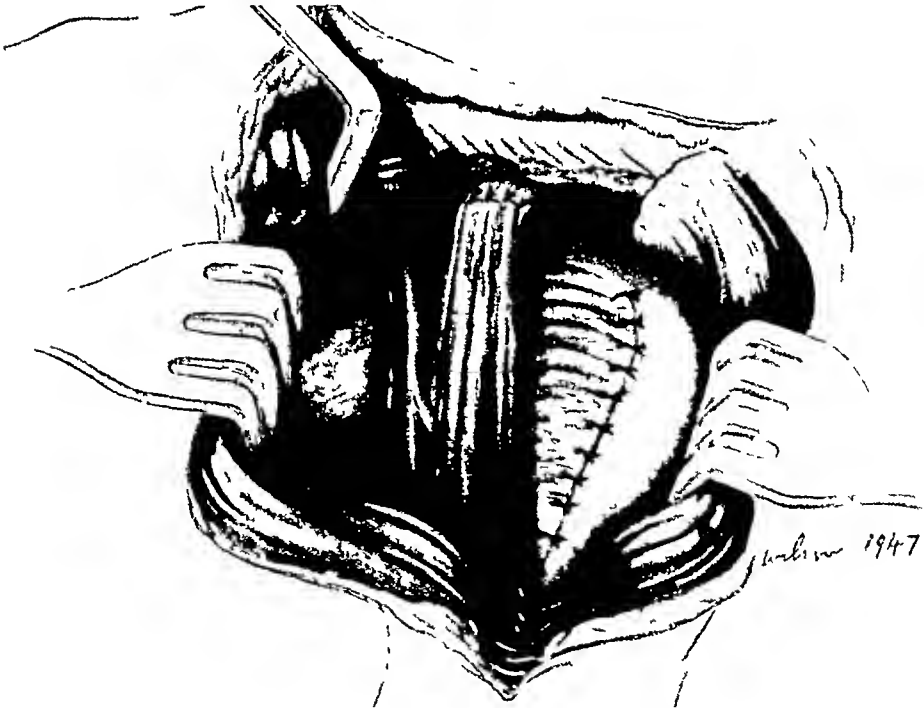


FIG 9

The muscle belly of the subscapularis is double-breasted over the capsule and stitched to tissues in the region of the greater tuberosity and bicipital groove. The conjoint tendon of coraco-brachialis and pectoralis minor is reattached to the coracoid.

of the reefing and muscle-shortening operation it should be possible to rotate the arm outwards to the neutral position, if the muscle is still more shortened a stubborn internal rotation contracture may persist for some time. The conjoint tendon is reattached to the coracoid, the deltoid to the clavicle and pectoralis major, and the wound is closed.

**After-treatment**—The arm is bandaged to the trunk with the forearm across the chest and the fingers on the opposite shoulder. Two or three six-inch crepe bandages, reinforced by strapping, maintain this degree of internal rotation for three or four weeks. Muscle power is then redeveloped, and movement restored by active graduated exercises under instruction. Two weeks later a more vigorous regime of gymnastics and games is instituted.

### COMMENTS

With minor personal modifications this is the operation taught by Harry Platt twenty-one years ago. He tells me that he has never had a recurrence, and Putti claimed 84 per cent of cures. In the early years of the second world war when it became apparent that the Nicola procedure would not withstand the strains of military life, the Putti-Platt and Bankart procedures were undertaken as a routine. The results of a series operated on by various surgeons in the Royal Air Force have been reviewed by my colleague, J. C. Adams. We do not claim that the Putti-Platt procedure is the only effective operation. There have been successes with many procedures. Nonetheless, on reviewing the literature, it is clear that the operations which achieve the most consistent success are those which produce a block to the exit of the head in front—a block of tight capsule, of fascia, of scar tissue, or of bone. The Putti-Platt procedure offers the further safeguard of shortening the subscapularis muscle which in most cases results in permanent limitation of external rotation movement. Unless these movements can be forced to their full range, and even beyond, dislocation cannot occur. The usual degree of limitation following operation, though apparent on examination, does not interfere with full function. The only valid criticism of the procedure is that several months may elapse before full movement is regained, and that very occasionally manipulation under anaesthesia may be required. This is indeed true. Nevertheless it seems a small price to pay for the cure of one of the most disabling of afflictions.

### SUMMARY

- 1 The history of the genesis of the Putti-Platt operation for habitual dislocation of the shoulder is outlined so far as it is known.
- 2 The operation is described and briefly commented upon.
- 3 Since there is both gleno-labial detachment and defect in the humeral head successful treatment depends upon
  - 1) a block to the exit of the humeral head in front,
  - and 2) limitation of external rotation movement.

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# RECURRENT DISLOCATION OF THE SHOULDER

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*Paper read at the Annual Meeting of the British Orthopaedic Association 1947*

This paper is based on a review of 180 cases of recurrent dislocation of the shoulder joint occurring in ground staff and air crew members of the Royal Air Force in the six-year period 1940 to 1945. During this period a total of 159 operations was performed for the relief of this disability. The task of analysing such a series has been facilitated by the fact that in a relatively small orthopaedic service such as was developed in the Royal Air Force under the direction of Sir Reginald Watson-Jones, orthopaedic surgeons were well known to each other and had frequent opportunities of discussing together all aspects of their work, and furthermore, by the standardised and very detailed system of case-recording which was in use at all the orthopaedic centres. These factors may reasonably be held to have safeguarded the accuracy of the findings here presented, and to render valid any conclusions based upon them. In recent years the main interest of recurrent dislocation of the shoulder has centred round its pathology, mechanism of production, and operative treatment, and it is with these aspects of the problem that the present study is concerned.

## PATHOLOGY

Many explanations have been put forward to account for the tendency to recurrent dislocation of the shoulder, some postulating changes in the capsule or ligaments, some in the bones, and others in the muscles. In fact, however, few of these theoretical explanations bear close analysis. Among recent contributions those of Bankart (1923, 1938) and Hill and Sachs (1940) demand close consideration.

Bankart holds the view that the pathology of all cases is the same, namely detachment of the glenoid labrum from the bone margin of the glenoid cavity in its anterior part. He believes that the dislocation is almost invariably anterior, whereas ordinary or non-recurrent dislocation is inferior. Bankart does not consider that bone changes play a significant part in the causation.

Hill and Sachs, working from the radiological view-point, emphasised the frequent occurrence of bone changes in the head of the humerus in the form of a defect in the postero-lateral aspect of its articular surface. Changes of this nature occurring in association with dislocation of the shoulder had been described previously by several observers, notably Flower (1861), Schultze (1914), and Pilz (1925). Nevertheless the frequency and significance of these changes did not receive general recognition because the defect is not shown in ordinary antero-posterior radiographs of the shoulder, and because the lesion is not easily exposed during operations on the joint through the usual anterior approach.

The bone lesion, according to the description of Hill and Sachs, consists of flattening or depression of the articular surface of the head of the humerus, usually involving its postero-lateral aspect. It is shown radiographically only by taking an antero-posterior film with the arm in internal rotation, or by taking an appropriate tangential projection. In such a film it has the appearance of a groove or depression at the upper and outer margin of the shadow of the humeral head. Furthermore, a sharp dense line of condensation is seen extending downwards from the top of the humeral head and parallel to the axis of the shaft (well shown in Figs 4 and 6). This represents compaction of the spongy bone previously occupying the space of the defect.



FIG 1



FIG 2

Antero-posterior radiograph of the shoulder with the arm in the neutral position (Fig 1) shows no defect of the humeral head. The same shoulder radiographed in 60 degrees of internal rotation (Fig 2) shows a well-defined defect at the upper and outer margin of the shadow of the humeral head.



FIG 3



FIG 4

Antero-posterior radiograph of shoulder with the arm in 90 degrees of internal rotation (Fig 3) shows no defect of the humeral head. In the position of 50 degrees of internal rotation (Fig 4) the defect is indicated by a dense line of condensation extending down from the top of the humeral head parallel with the shaft.

The cause of this defect has been a matter of some uncertainty Hill and Sachs believed that it was due to compression fracture of the comparatively soft bone comprising the posterolateral portion of the head of the humerus, caused by impact against the glenoid margin during violent dislocation In support of this view they cited radiographic evidence that such a defect might be present immediately after a single injury to a shoulder joint which was proved to be normal before the injury



FIG 5



FIG 6

Antero posterior radiograph of shoulder in 20 degrees of internal rotation (Fig 5) shows no defect but the same shoulder in 60 degrees of internal rotation (Fig 6) shows a large defect in the humeral head

These two contributions have added fresh stimulus to the study of the pathology of recurrent dislocation of the shoulder, and in the cases under review particular care was taken during operative exposure to note pathological findings which might have bearing on the causation of redislocation Analysis of the abnormal findings is shown in Table I

TABLE I  
ANALYSIS OF ABNORMAL FINDINGS IN 180 CASES OF  
RECURRENT DISLOCATION OF THE SHOULDER

Type of lesion	Number of cases suitably examined	Lesion present		Lesion absent	
		Number	Per cent	Number	Per cent
Detachment of glenoid labrum and anterior capsular stripping	79	69	87	10	13
Bone defect of head of humerus	68	56	82	12	18

**Pathological findings**—The glenoid labrum was exposed and closely examined in seventy-nine cases In sixty-nine cases (87 per cent) detachment of the labrum from the

bone margin of the glenoid was demonstrated. In ten cases (13 per cent) the labrum was found to be normally attached. The lesion, when present, had the characteristics described by Bankart. The extent of detachment was variable, its position was always on the anterior half of the circumference of the glenoid margin, either directly anterior or antero-inferior. Not uncommonly the detached portion of the labrum was found to be attenuated, presumably the result of repeated trauma.

*Capsule*—In association with detachment of the glenoid labrum there was invariably some degree of stripping of the anterior part of the capsule from the front of the neck of the scapula. This finding has been mentioned by other observers, notably Bost and Inman (1942). It can be regarded as an integral part of the lesion described by Bankart.

*Head of the humerus*—This was studied adequately by radiographic examination in sixty-eight cases. For reasons which are discussed below, radiographic study was not accepted as adequate unless the series of films included at least one, and preferably more than one, projection with the humerus in a position of internal rotation between 50 and 80 degrees. In fifty-six of the cases so examined (82 per cent), a well-defined bone defect was shown to be present. In twelve cases (18 per cent) no defect was demonstrated. It is particularly worthy of note that a defect was present in every case which at operation was found to show no lesion of the glenoid labrum. The characteristics of the defect corresponded closely with the description of Hill and Sachs. Typical examples are shown in Figs 2, 4, 6, and 9.

*The bone margin of the glenoid* was found to be rounded and eburnated in a proportion of cases in which there was detachment of the glenoid labrum. This finding was more common and more pronounced when dislocation had recurred with great frequency, thus suggesting that it is a secondary change due to repeated trauma.

**Discussion**—Modern conceptions of the pathology of recurrent dislocation of the shoulder may now be reconsidered in the light of this study of 180 cases. In the first place there appears to be general agreement that the tendency to redislocation always follows upon injury. In this series the condition never developed spontaneously. The injury has usually been a violent initial dislocation, apparently causing damage which is not repaired by the natural processes of healing, thus differing from simple or non-recurrent dislocation in which damage is repaired and the joint restored to normal.

It is also established with reasonable certainty that detachment of the glenoid labrum from the margin of the glenoid cavity, associated with stripping of the anterior part of the capsule from the front of the scapular neck, is a major causative factor in the large majority of cases. But it is not possible to accept the view that this lesion alone is responsible for the tendency to redislocation in every case. It has been shown that in approximately 13 per cent of cases, in which careful examination of the area was made, the glenoid labrum was attached in a normal manner to the anterior glenoid margin. In these cases, at least, some other factor must be responsible, and there is evidence to suggest that this factor is the defect in the articular surface of the head of the humerus. This was the only lesion found consistently in shoulder joints which showed no detachment of the glenoid labrum. Moreover, as will be shown later, it is a lesion which itself is capable of causing redislocation and which, like detachment of the labrum, is an abnormality incapable of restoration to normal by the natural processes of healing.

Radiographic demonstration of the bone change requires further description. Careful study was made of all radiographs showing the defect, and the degree of rotation of the humerus in each film determined accurately by comparison of the outline of the shadow with radiographs of a normal dried humerus in known degrees of rotation. In this way it was established that the defect is most often demonstrated in profile when antero-posterior radiographs are made with the humerus in 60 to 70 degrees of internal rotation. It was found also that there is slight individual variation in the position of the defect, and consequently

in the radiographic positioning required to demonstrate it. Thus in a few cases the defect was shown most clearly in antero-posterior projections with the humerus in only 50 degrees of internal rotation. Occasionally it was best seen with the humerus in as much as 80 degrees



FIG 7



FIG 8



FIG 9

There is a very large defect in the head of the humerus which is shown only in 60 degrees internal rotation (Fig 9) and is completely concealed in neutral rotation (Fig 7) and external rotation (Fig 8)

of internal rotation. Only larger defects were demonstrable in films taken with the arm in full internal rotation (100 degrees).

Because of these variations a small defect may easily be overlooked unless several projections are made showing the humerus in positions between 50 degrees and 80 degrees of internal rotation. For this reason it is probable that the incidence of the defect has been

underestimated by most observers. The true incidence may well be even higher than the 82 per cent recorded in this series.

These two lesions—anterior detachment of the glenoid labrum and bone defect of the humeral head—are often associated in the same shoulder, but they do not necessarily arise simultaneously. It seems probable that in some cases detachment of the labrum occurs first, and that subsequent impacts against the unprotected bone margin of the glenoid cavity cause secondary flattening of part of the humeral head. Once this has occurred it is reasonable to expect an increased tendency to redislocation. Moreover, the larger the defect the

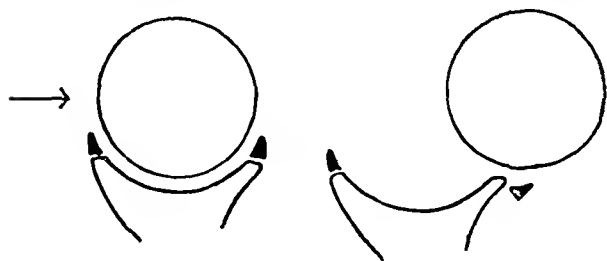


FIG 10

Diagram to show manner in which anterior detachment of the labrum may predispose to redislocation

greater is the tendency to dislocation. The history so often given in cases of recurrent dislocation supports this hypothesis. At first, dislocation occurs infrequently; this corresponds to the stage of simple detachment of the glenoid labrum. Later, often quite suddenly, the frequency of dislocation is greatly increased; this coincides with the development of a defect in the humeral head. Finally, instability of the joint becomes

increasingly disabling; this is explained by gradual enlargement of the defect.

It remains now to consider the manner in which these abnormalities predispose to recurrent dislocation. Detachment of the glenoid labrum removes a small but significant buttress guarding the anterior edge of the glenoid cavity. When the head of the humerus is forced in the direction of the lesion, by whatever mechanism, the detached segment of labrum is displaced over the bone margin of the glenoid into a position in front of the neck of the scapula (Fig 10). A deficiency is thus created in the anterior rim of the cavity over which the head of the humerus may escape, though it remains within the joint capsule.

A defect of the head of the humerus acts in a comparable manner (Fig 11). In this case, instead of the buttress being removed, there is deficiency of the part of the head which normally would engage with the buttress. The head is thus able to slide over the anterior margin out of the glenoid cavity. This can occur only when the humerus is in such a position, relative to the scapula, that the flattened defect is in engagement with the anterior glenoid margin. This condition is fulfilled when the arm is in external rotation and abduction. Again the dislocation is always intra-capsular.

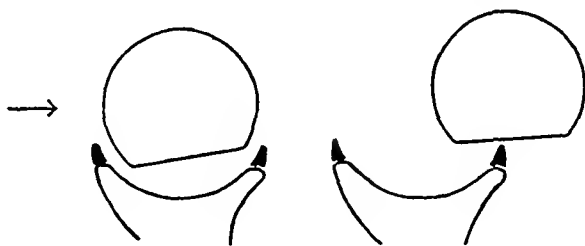


FIG 11

Diagram to show manner in which postero lateral defect of the humeral head may predispose to redislocation

### MECHANISM OF PRODUCTION

In the past there has been no general agreement as to the mechanism of production of the initial dislocation. In many cases it is difficult or impossible to elicit from the patient an accurate account of the movements sustained by the arm at the time of injury. However, from careful study of the case histories in the present review it has been possible to select a number of cases in which the exact mechanics of injury are known with certainty. These examples are insufficient in number to provide a reliable estimate of the relative frequency of each mechanism, but they do indicate clearly that the mechanism of dislocation is by no means constant, and that recurrent dislocation may be initiated by a number of different



types of injury There are clear examples in this series of initial dislocation being due to five types of injury

**1 Fall on the abducted arm (without hyper-abduction)**—In order to understand how such a fall may cause anterior dislocation it is necessary to bear in mind that the plane of the gleno-humeral joint is not in the sagittal plane of the body, but is set at an angle of approximately 45 degrees to the sagittal plane (The angle is not of course constant, owing to mobility of the scapula) Therefore, a telescoping force applied to the abducted humerus, such as occurs in a fall on the outstretched arm, or on the outwardly directed elbow, is converted by resistance of the glenoid fossa into an antero-medial force acting in the plane of the gleno-humeral joint (Fig 12) This may result in forward dislocation of the humeral head Such type of injury is obviously liable to cause damage both to the anterior glenoid margin and to the head of the humerus It was by far the most common cause of recurrent anterior dislocation

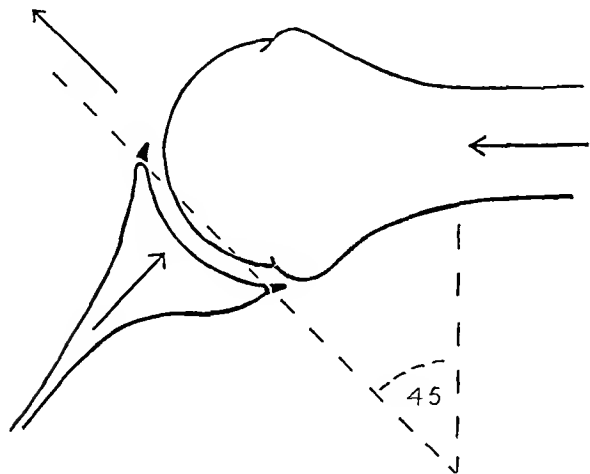


FIG 12

Diagram to show plane of gleno humeral joint as seen in horizontal section with the humerus abducted through 90 degrees A force acting in the coronal plane through the humerus is met by the resistance of the glenoid fossa, the resultant force acts in the plane of the gleno-humeral joint

result from a fall directly on the back of the shoulder, or by a fall on the elbow which is directed backwards As it is driven forwards out of the glenoid cavity the head of the humerus may shear the glenoid labrum from the bone, or the head of the humerus may sustain a compression fracture, or both injuries may occur This mechanism undoubtedly operates in some cases but it cannot be regarded as the sole cause, or even the most common cause, of recurrent anterior dislocation Indeed in this series it was relatively infrequent

**3 Hyper-extension of the abducted arm**—Two similar examples of this mechanism may be quoted In each case the patient was the pilot of a light aircraft While manoeuvring the aircraft on the ground, he put the arm out sideways from the cockpit (90 degrees abduction with the arm in the coronal plane) The force of the slip-stream hyper-extended

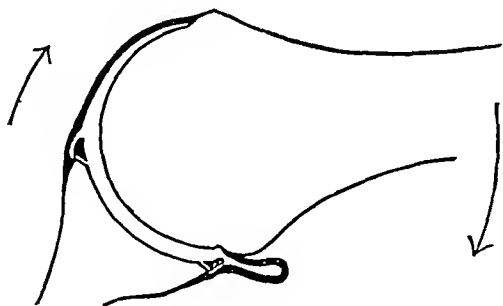


FIG 13

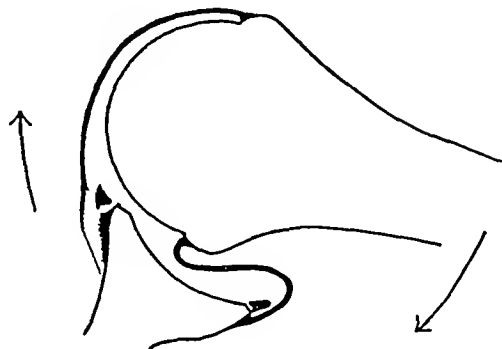


FIG 14

Diagram to show how hyper-extension in abduction may result in anterior dislocation Hyper-extension causes separation of the capsular attachments anteriorly while the head in slipping forwards round a fulcrum formed by muscle attachments, shears off the glenoid labrum

significance because it is in full external rotation that a bone defect of the humeral head comes into engagement with the glenoid cavity and may permit redislocation *Pain*—A subjective symptom such as pain is always difficult to assess Nevertheless the observation is inescapable that persistent aching pain in the shoulder region is of disturbing frequency after the Nicola operation In this series, disability due to pain was considered to be of material degree in twelve cases (20 per cent of the fifty-nine cases observed for more than two years) The pain may result from irritation of the joint due to injury to articular cartilage during the operation, or from disturbance of the normal anatomy due to interposition of the biceps tendon between its surfaces

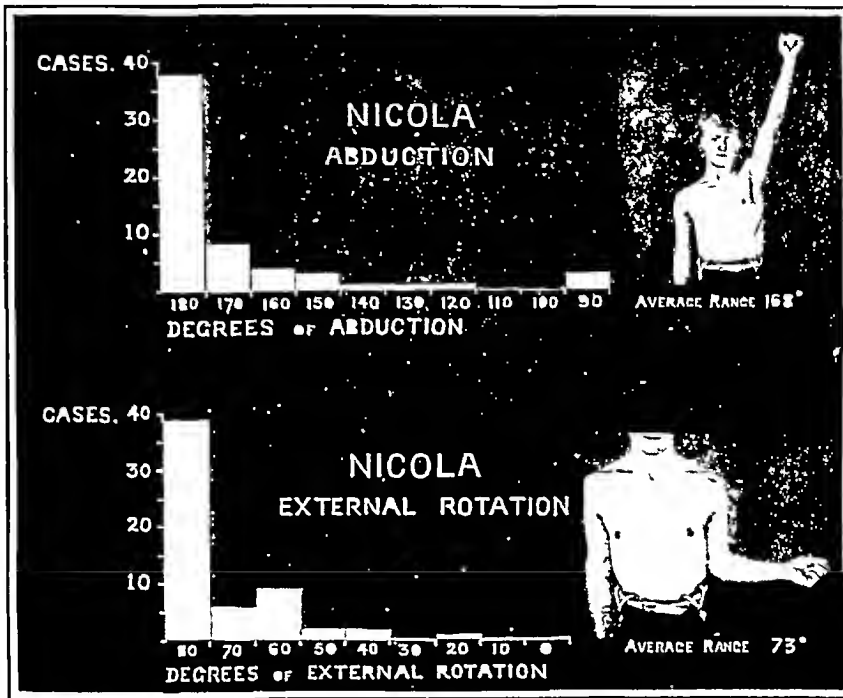


FIG 16

Range of abduction and external rotation movement two to five years after Nicola operation

**The Bankart operation**—The results of this operation have been satisfactory *Stability*—Of eighteen cases of operation followed up for more than two years there was only one recurrence and this was almost certainly due to poor technique because at subsequent re-operation extensive anterior detachment of the glenoid labrum was found still to be present *Mobility*—A normal range of abduction is usually regained The average range in eighteen cases was 166 degrees Some degree of impairment of external rotation is usual In only two cases was the normal range regained The average range of external rotation in eighteen cases was 51 degrees (Fig 17) *Pain*—In no case was pain found to be a significant feature following the Bankart operation

For details of the technique of Bankart's operation reference should be made to his original accounts It should be noted, however, that in longstanding cases the glenoid labrum may be so attenuated as the result of repeated trauma that it is impracticable to reattach it to the glenoid margin In such cases the capsule itself is sutured to the front of the glenoid rim The operation is not quite universally applicable, for occasionally the glenoid labrum is found to be normally attached These are the cases in which it is believed that repeated dislocation is due mainly to a defect of the humeral head Clearly some other procedure must be adopted in such a case

**The Putti-Platt operation**—This operation has proved satisfactory in the cases under review. The subscapularis muscle is divided about one inch from its insertion. The front of the neck of the scapula is rawed with an osteotome, adjacent soft tissues are scarified, and the distal portion of the subscapularis muscle is sutured firmly to periosteum and soft tissues in front of the neck of the scapula, the arm being maintained in internal rotation. The proximal portion of the subscapularis is then sutured to the region of the lesser tuberosity, thus overlapping the distal portion. The arm is bandaged to the trunk in internal rotation for a period of four to six weeks, after which active exercises are commenced.

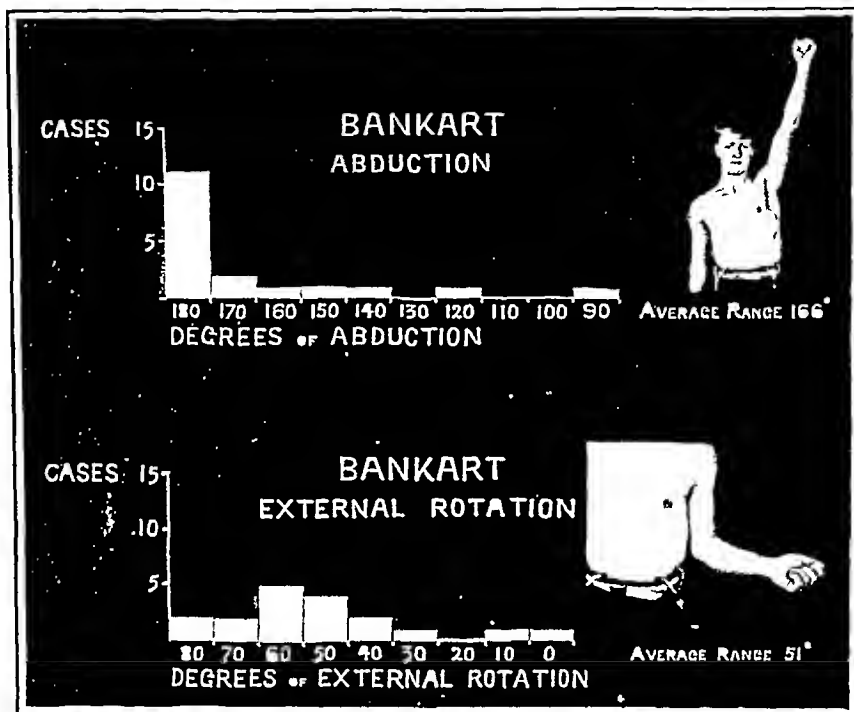


FIG 17

Range of abduction and external rotation movement two to five years after Bankart operation

The effect of this procedure is twofold. Anchoring of the tendon of the subscapularis to the front of the neck of the scapula amounts to the formation of a strong ligament which effectively prevents full external rotation at the gleno-humeral joint. This is one of the purposes of the operation, and it is a strong safeguard against recurrence of dislocation, for it is in external rotation that the humerus with a defect in its articular surface is liable to slip forwards out of the glenoid fossa. Secondly, the operation results in the formation of a firm fibrous buttress in the very region where support is required, namely at the anterior margin of the glenoid fossa. **Stability**—In thirty-seven cases of this procedure followed up for two or more years, there were two recurrences. In both instances redislocation resulted from moderately severe violence, which may or may not have been sufficient to cause dislocation of a normal shoulder. In one case the patient sustained severe external rotation strain of the shoulder joint three months after operation while still undergoing rehabilitation. In the second case the shoulder was entirely satisfactory for seventeen months after operation, but it dislocated again as the result of a fall on the outstretched hand. In both cases the instability became recurrent and further treatment was necessary. It is interesting to note that in both these unsuccessful cases a full range of external rotation had been regained after operation. This suggests that the technique may have been imperfect in that the

subscapularis tendon may not have been sutured tightly enough to the anterior scapular region  
*Mobility*—A normal or nearly normal range of abduction has been regained in the great majority of cases. The average range was 170 degrees. External rotation is almost invariably limited, often very considerably. The average range regained was 40 degrees (Fig 18)  
*Pain*—In no case was pain found to be a significant feature following the Putti-Platt operation

**Choice of operation**—Comparison of the results of the three operations which have been considered indicates that the Nicola operation is much less certain in its results than

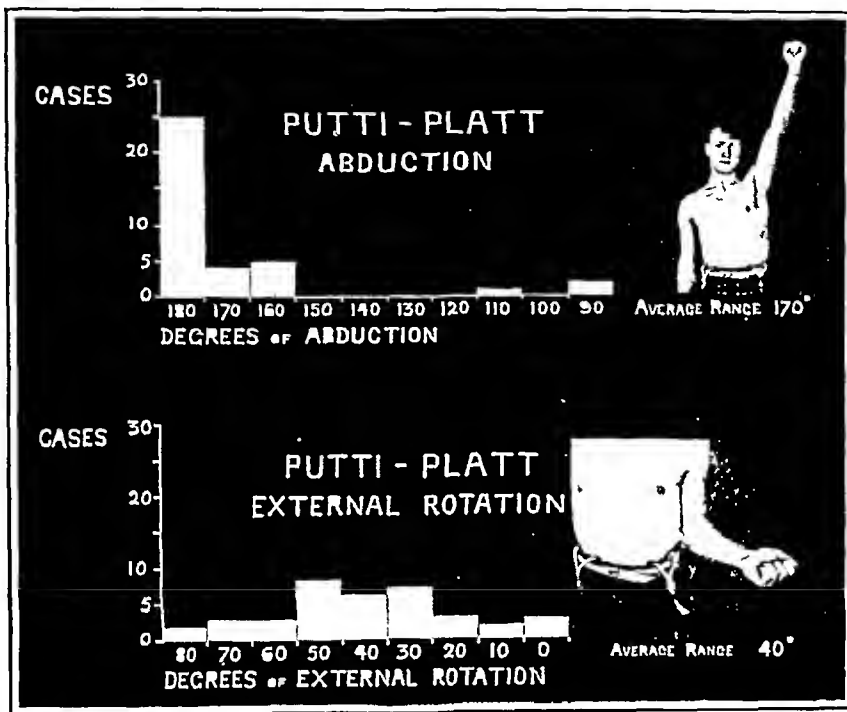


FIG 18

Range of abduction and external rotation movement two to five years after Putti-Platt operation

either the Bankart or Putti-Platt operation. Improvement in results might perhaps be gained by more careful selection of cases, but the multiplicity of factors involved makes it difficult to predict which case is likely to be treated successfully by this procedure. A further objection lies in the fact that the operation disturbs the normal anatomy of the joint, and may cause aching pain which is persistent and disabling. In view of these facts it is believed that the Nicola operation is seldom, if ever, indicated in the treatment of recurrent dislocation of the shoulder.

Comparing the Bankart and Putti-Platt operations the evidence suggests that there is little to choose between them with regard to results, which have been satisfactory in over 95 per cent of cases. They both have the advantage that exact pathology may be determined at operation. The Putti-Platt operation is rather more easy to perform efficiently than the Bankart operation, especially if a right-angled electrically driven dental handpiece is not available for making holes in the glenoid margin. Moreover it is applicable to every case, whether caused by detachment of the glenoid labrum or by defect of the humeral head. Against the Putti-Platt operation may be brought the argument that it results in considerable restriction of external rotation movement. Certainly there is a greater limitation of this movement than is usual after the Bankart operation. In practice, however, the disability

from this cause is found to be of a minor degree. In the words of a patient whose final range of external rotation was only 10 degrees "The almost total lack of external rotation does not seem to affect either my work or sports." There is no doubt that this restriction of movement is a price willingly paid for stability and full confidence in the shoulder.

### SUMMARY AND CONCLUSIONS

A review of the pathology, mechanism, and operative treatment of recurrent dislocation of the shoulder, based on an analysis of 180 cases, with 159 operations, is presented. From this analysis the following conclusions have been made and appear to be substantiated.

1 The pathology comprises two important elements: (a) anterior detachment of the glenoid labrum from the bone margin of the glenoid, associated with some degree of stripping of the anterior part of the capsule from the front of the neck of the scapula, found in 87 per cent of cases examined adequately at operation, (b) defect or flattening of the postero-lateral aspect of the articular surface of the head of the humerus which engages with the glenoid cavity when the arm is in external rotation and abduction, this defect is demonstrated most readily in antero-posterior radiographs taken with the humerus in 60 to 70 degrees of internal rotation and was shown to be present in 82 per cent of cases which had been subjected to adequate radiographic examination.

2 The frequency of the humeral head defect has been under-estimated in the past, because of the difficulty of demonstrating it, particularly when the defect is small.

3 Either type of lesion alone may predispose to recurrence of the dislocation.

4 Both types of lesion are often present in the same shoulder. When this is the case the tendency to redislocation is great.

5 The initial dislocation, which results in the development of one or both these persistent structural abnormalities, may be due to very different types of injury, the commonest of which is a fall on the outstretched hand. The factor common to all these injuries is a resultant force acting on the humeral head in the direction of the anterior glenoid margin.

6 In the treatment of recurrent dislocation of the shoulder joint the Nicola operation is unreliable, and it may be associated with a recurrence rate as high as 36 per cent. It is believed that continued instability after this operation is usually due to the presence of a defect of the humeral head.

7 Operative treatment should aim at repairing, or nullifying, the effects of both types of lesion. For anterior detachment of the labrum this involves either suturing the labrum back to the glenoid margin, or constructing some form of anterior buttress, fibrous or bony. For humeral head defects it necessitates some procedure designed to limit external rotation, thus preventing the defect from coming into engagement with the glenoid cavity. Such limitation of external rotation does not constitute a significant disability.

It is with much pleasure that I acknowledge my indebtedness to Sir Reginald Watson-Jones for facilitating this review in every possible way, and for constant stimulation and encouragement, and to Mr H. Osmond-Clarke for valuable advice and assistance. I wish also to extend my thanks to the individual surgeons of the Royal Air Force orthopaedic units for allowing me to review their cases, and in particular to Mr N. Vere-Hodge who has been of great assistance in helping to trace these cases for follow-up study.

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# RECURRENT DISLOCATION OF THE SHOULDER

## Lesions Discovered in Seventeen Cases Surgery Employed and Intermediate Report on Results

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Sixteen consecutive cases of recurrent dislocation of the shoulder joint have been operated upon using the antero-medial approach. This approach gives the operator an opportunity not only to discover in each case the cause of the recurring dislocation but also to deal with such lesions in the appropriate manner. The superficial muscle plane is split in the delto-pectoral clef for six to seven inches. The intermediate muscle plane is dealt with by detaching the distal half-inch of the coracoid process with the origins of the coraco-brachialis and short head of the biceps and having secured the lateral fascial extension turning these downwards and inwards. The third muscle plane consists of the subscapularis and its tendon: this is incised vertically for two inches and with it the underlying and adherent anterior capsule of the shoulder joint. A good anterior view of the head of the humerus and glenoid is then secured. To view the posterior surface of the head it is necessary to incise some of the anterior fibres of the supraspinatus: with full external rotation adequate inspection can be made. This is particularly easy when there is a pronounced groove or notch on this surface.

The information obtained in these seventeen cases revealed that the cause of recurring dislocation was always (1) Some lesion of the anterior support of the head of the humerus and/or (2) a groove in the posterior surface of the head of the humerus which made the dislocation possible with less anterior displacement of the humerus. The lesion of the anterior support of the head of the humerus was not always the same, although in the vast majority of cases it consisted of detachment of structures from the anterior lip of the glenoid (Bankart's lesion). In those cases where no detachment of the anterior structures could be found but in which there was a defect in the head of the humerus (Group 3) it is presumed that a stretched capsule accounted for loss of anterior support to the head of the humerus. The precise lesions found were (Figs. 1-4).

*Group 1* Detachment of the glenoid labrum, capsule and periosteum from the lip of the glenoid plus a groove on the posterior surface of the head of the humerus—eight cases.

*Group 2* Detachment of the glenoid labrum and capsule alone—five cases.

*Group 3* Groove on the posterior surface of the head of the humerus alone—three cases.

*Group 4* Detachment of the subscapularis muscle in its lower half from its insertion into the lesser tuberosity—one case.

**Detachment of labrum**—Detachment of the glenoid labrum and capsule on which Bankart has laid so much stress, deserves full description in order to give the widespread recognition which it deserves. The glenoid labrum and capsule over the lower three-quarters of their attachment to the anterior lip of the glenoid are detached. With these is raised the periosteum on the front of the neck of the scapula over an area approximately one and a half inches by one inch. The bare bone is an interesting feature in these cases. In only two cases did there appear to be any fibrous covering to the exposed bone, although the detachment must have been present for some years. A deep pocket is formed between the detached periosteum and labrum on the one hand, and the neck of the scapula on the other. Periosteal new bone is often laid down at the limit of periosteal separation. This can be felt at operation and has been detected in radiographs on several occasions (Fig. 7).

**Groove in humerus and "hatchet head"**—A groove on the posterior surface of the head of the humerus is the usual finding. It is well illustrated in Fig 6 and its floor has invariably consisted of bare bone. It is to be noted that this groove, when at all pronounced, can be illustrated in pre-operative radiographs. With the X-ray tube

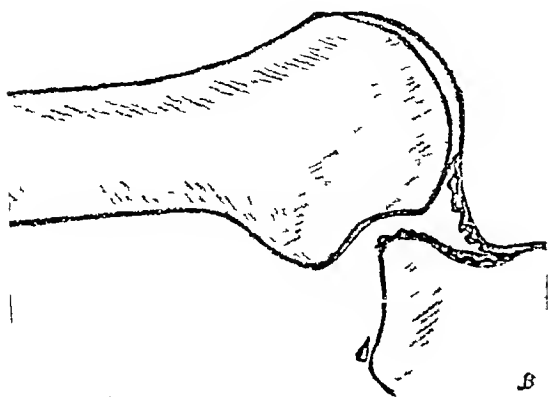


FIG 1

Dislocation with detachment of labrum and groove in humerus—eight cases (48 per cent)

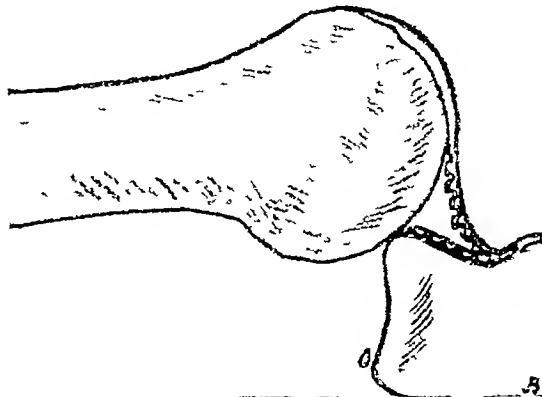


FIG 2

Dislocation with detachment of labrum and periosteum alone—five cases (30 per cent)

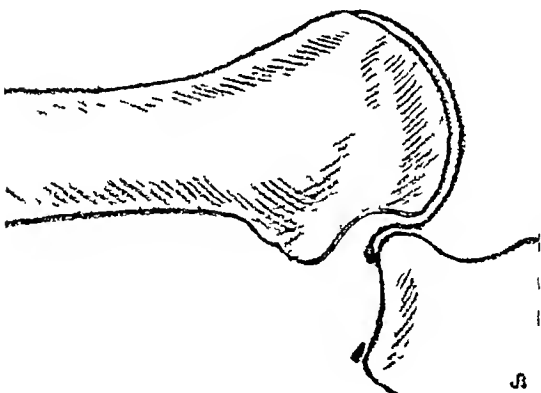


FIG 3

Dislocation with groove in humerus alone—three cases (18 per cent)

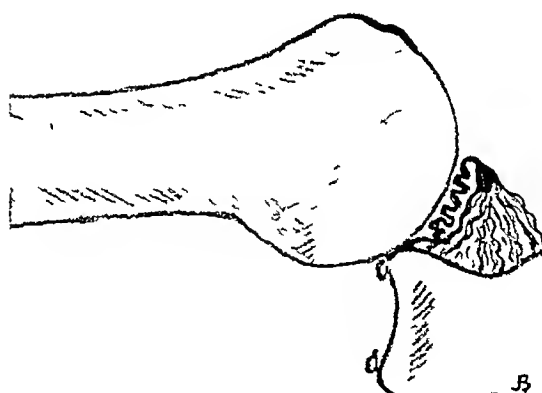


FIG 4

Dislocation with detachment of subscapularis—one case (6 per cent)

in the axilla, the arm abducted to 40 degrees, and the X-ray cassette above the shoulder of the sitting patient, an admirable view of the groove may be obtained. An antero-posterior radiograph often shows marked flattening of the head superiorly and laterally, this being caused by the upper limit of the groove, and giving the "hatchet head" appearance (Fig 5). It will be noted that in three cases, the dislocation was occurring with an intact anterior capsule, although in each case assisted by a pronounced groove on the posterior surface of the head of the humerus.

**Avulsion of subscapularis**—There was one interesting case where loss of the anterior support to the head of the humerus resulted from detachment of the tendon of insertion of the subscapularis, with a flake of bone, from the lesser tuberosity. When the coracobrachialis and short head of biceps were retracted, there was an unimpeded view into the lower half of the joint (Fig 8).



FIG 5

Case 3—Right shoulder the site of ten dislocations in five years. The anteroposterior radiograph shows the upper limit of the posterior groove in the head of the humerus giving rise to the appearance described as the "hatchet head".



FIG 6

Post-mortem specimen. Note pronounced groove on the posterior surface of the head of the humerus, and the flattened anterior lip of the glenoid compared with overhanging posterior lip. (Kind permission of British Journal of Surgery.)



FIG 7

Case 6—Subperiosteal new bone formation at the limit of periosteal detachment from the neck of the scapula.

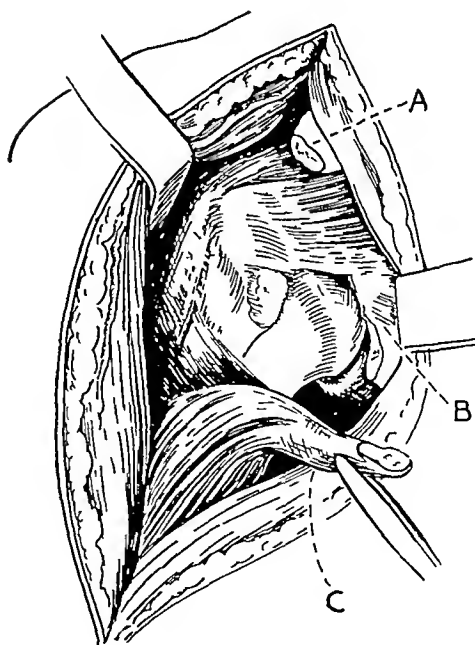


FIG 8

Case 12—Detachment of half the subscapularis (B) from the lesser tuberosity of the humerus (A coracoid C coraco brachialis).



### OPERATIVE TREATMENT

The operation performed on these seventeen cases depended naturally on the cause found on exploration. For the detached glenoid labrum a modification of Bankart's operation was employed. It was found possible to remove part of the cortex of the neck of the scapula to form two horizontal gutters, leaving a stout bridge of bone coming right up to the lip of the glenoid between them. A stout No. 6 silk thread was passed under this bridge at its glenoid end, and used to tie the labrum, periosteum, and capsule firmly down in place. To execute this manoeuvre, it will be found necessary to observe the following points:

- 1 Keep the head of the humerus in full internal rotation, which brings the neck of the scapula into better view.
- 2 Employ a Travers fixed retractor between the capsule attached to the head of the humerus laterally, and the detached coraco-brachialis and short head of biceps medially. This also keeps the more superficial muscles well retracted.
- 3 Use a quarter-inch chisel, driven into the body of the scapula, to retract the detached glenoid labrum and subscapularis. This gives an admirable view of the neck of the scapula (Fig. 9).
- 4 Employ a sucker to keep the wound dry.
- 5 Use a strong cutting hook, pierced at the tip, to pass the silk suture through the cancellous bone beneath the cortical bridge. (Those illustrated in Fig. 11 were made from Steinmann pins.)

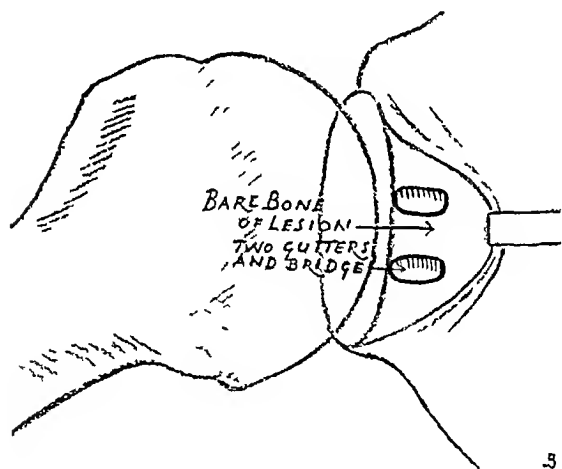


FIG 9

Repair of detachment of the labrum capsule and periosteum (Bankart's lesion). The bare area is displayed by a chisel in the bone acting as a retractor. Two gutters are gouged in the neck of the scapula. The suture will be passed beneath the intervening bridge at its glenoid end.

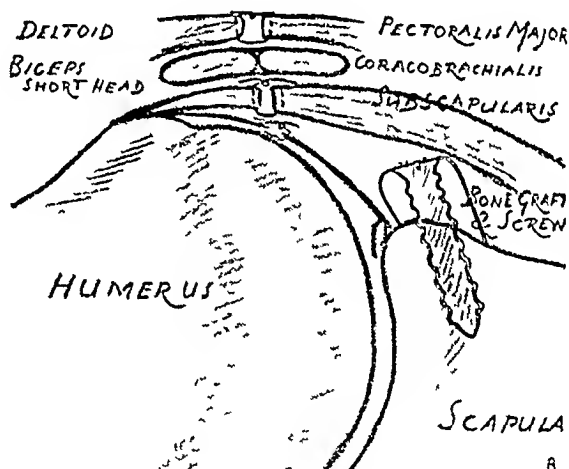


FIG 10

When the lesion is not a detachment of the labrum but a groove in the head of the humerus, an anterior bone block is advisable. An iliac bone graft to the neck of the scapula prolongs the anterior lip of the glenoid. The diagram shows the surgical approach and the graft and screw.

Two bridges have been constructed in some cases but one is sufficient tax on the operator. The subscapularis has to be separated from the capsule before the suture is tied deep to this muscle. This variant of Bankart's operation avoids working on the cartilage surface of the joint, and the greater roughening of the neck of the scapula can result only in more effective reattachment of the detached structures. It is felt that a silk suture is better than the use of staples, as employed by the Johannesburg school of orthopaedic surgeons. Such staples, if they become detached, are poor neighbours to a variety of axillary structures<sup>1</sup> (Fig. 12).

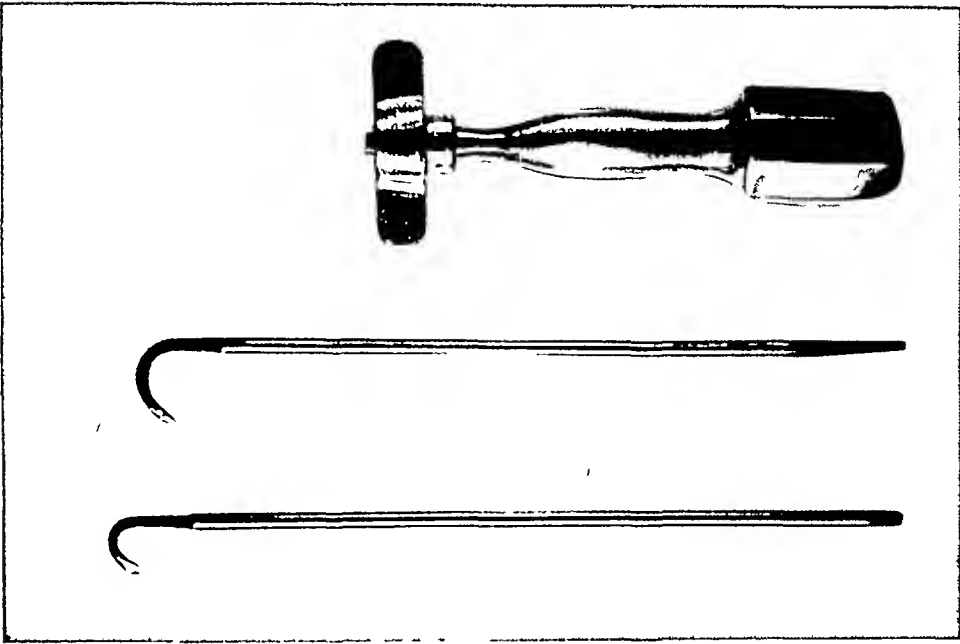


FIG 11

The difficulty of passing a suture through the bone is solved by using strong cutting hooks pierced behind the point made from Steinmann pins and held in a Steinmann pin handle



FIG 12

Antero posterior and supero inferior radiographs six years after repair of Bankart's lesion by three staples according to the technique of the Johannesburg school. A fourth staple used for reattaching the coracoid process has become detached and is in two pieces. No recurrence of dislocation. Full range of movement. Some slight aching.

When a humeral groove is present in addition to a lesion of the anterior support of the head of the humerus, treatment of the latter alone was deemed sufficient. When dislocation was occurring within what appeared to be no more than stretched anterior tissues, and was primarily attributable to the humeral groove, some other form of surgery was considered necessary. Multiple osteotomy of the coracoid process was performed in two cases but more recently a bone graft, comprising the whole thickness of the iliac crest, has been screwed on to the anterior surface of the neck of the scapula beneath the subscapularis muscle, the periosteum being incised vertically to give bone contact (Fig 10).

## ANALYSIS OF SEVENTEEN CASES OF RECURRENT DISLOCATION OF THE SHOULDER

Case No	Age	Sex	Occupation	Previous operations	Findings at operation			Operation performed	Interval since operation	Follow-up report
					Bankart's lesion	Groove on head of humerus	Other lesion			
1	—	M	Army	—	Yes	Yes (shallow)	Loose body	Bankart's operation	4 years	No reply
2	22	M	Army Clerk	—	Yes	None	—	Bankart's operation	2½ years	No dislocation, vigorous tennis occasional dull ache
3	27	M	Army Building Maintenance	—	None	Yes (deep)	—	Coracoid osteotomy	2½ years	No dislocation, as strong as other, no complaint
4	27	M	Army Labourer	—	None	Yes (shallow)	Loose body	Coracoid osteotomy	2½ years	No dislocation, no complaint
5	26	M	Army Upholsterer	—	Yes	None	—	Bankart's operation	2½ years	No dislocation aches with hard use
6	24	M	Army Manufacturer	Clairmont operation	Yes	Yes (moderate)	—	Bankart's operation	2½ years	No dislocations plays rugby, no complaints
7	29	M	Army Truck Driver	—	Yes	None	—	Bankart's operation	2 years	No dislocation pick-axe work, cwt sacks, no complaints
8	27	M	Army Tool Grinder	Nicola operation	Yes	Yes	—	Bankart's operation	2 years	No dislocation, heavy lifting, cricket no complaints
9	17	M	Clerk	—	Yes but labrum in situ	Yes	—	Bankart's operation	1½ years	No dislocation, swimming, occasional ache
10	24	M	Research Chemist	—	None	Yes	—	Iliac bone graft to scapula	1½ years	No dislocations, can bowl over-arm not as strong as normal
11	31	M	Army Shop Assistant	—	Yes	? (No note)	—	Bankart's operation	1½ years	No dislocation no sport feeling of weakness in shoulder
12	17	F	Schoolgirl	—	None	None	Lower half of subscapularis detached from lesser tuberosity	Subscapularis re-attached	½ year	No dislocation some ache with violent use
13	52	M	Carpenter (Tabetic patient)	—	Yes Flake of bone detached as well	None	—	Iliac bone graft to scapula (Tabetic patient)	½ year	No dislocation, hard at work with no complaints
14	23	M	Leather Dresser	—	Yes	Yes (deep)	—	Bankart's operation	4 months	Too recent for follow-up
15	22	M	Builder's Labourer	—	Yes	Yes (shallow)	—	Bankart's operation	3 months	
16	23	M	Engineer	—	Yes	Yes (moderate)	—	Bankart's operation	1 month	
17	27	M	Builder	—	Yes	Yes (shallow)	—	Bankart's operation	1 month	

The one case of detachment of the insertion of subscapularis from the lesser tuberosity of the humerus was dealt with by reattachment with a silk suture through bone

In closing these wounds, the capsule and subscapularis were always sutured independently and the detached portion of the coracoid process was reattached. Far from the subscapularis being a causative factor in dislocation as was once taught, its careful repair is an important point in ensuring a successful result. The anatomical repair of both the lesion, and the incision of approach, should be complete.

The arm was always kept by the side for four to six weeks. After this, physiotherapy and exercises were used unrestrainedly to regain movement, almost a full range being obtained in about six weeks. The period of four to six weeks with the arm by the side would appear to be essential in order to obtain biological repair of the lesion. No matter how well placed and securely tied, a single suture of silk cannot be relied upon for repair.

### RESULTS OF TREATMENT

There was no epileptic case in this series. There was one case of a tabetic patient with a Charcot's knee. Two cases had previously been subjected to unsuccessful operations, one a Nicola operation and the other a Clairmont operation. None of the twelve cases which have been traced in the follow-up has had recurrence of the dislocation. All appear very satisfied with their results. One is playing rugby football again (not first-class rugby as formerly, but after an unsuccessful Clairmont operation and a successful Bankart operation, he is loath to hazard too much on the field of sport). All are back at their former employment, sometimes of a very strenuous nature.

### DISCUSSION

It would appear from these cases that some lesion of the anterior support of the humeral head is the common cause of recurrent dislocation of the shoulder (Bankart's lesion in thirteen out of seventeen cases), and that the notch or groove on the posterior surface of the head of the humerus is usually present and is an important factor in making dislocation possible with less forward displacement of the humeral head. In some cases, recurrent dislocation occurs with a pronounced humeral groove and no detectable lesion of the anterior capsule or of the subscapularis muscle. In these alone is it necessary to do more than repair the lesion to the structures normally supporting the head anteriorly. In this series, dislocation has not recurred since operation, although wherever possible, surgery was confined to simple repair with a silk suture (Bankart's operation).

The lesion to the tissues supporting the head of the humerus anteriorly undoubtedly occurs at the initial dislocation and it is to be presumed that the posterior humeral groove has a similar traumatic origin. Is it of the nature of a depression fracture, the cartilage being shed subsequently? Although in two cases only was a small loose body removed from the joint, this explanation would appear to be the most reasonable. The congenital origin of the posterior groove, as postulated by Tavernier and his colleagues, does not seem probable.

While in all these cases we have found certain lesions, which are being widely recognised as commonly associated with the condition of recurrent dislocation of the shoulder, we are still in ignorance as to the frequency of such lesions in simple dislocations of the shoulder. In one case of acute dislocation of the shoulder, associated with a fractured neck, in which open operation was needed to reduce the dislocation, classical detachment of the labrum was revealed at operation. Was this the initial lesion in a recurring dislocation of the shoulder? Do degrees of separation of the labrum occur without recurrence of the dislocation? In the absence of a humeral groove, does the shoulder often remain stable in the presence of a separated labrum and capsule? Can the theory of a difference in the type of trauma in simple and recurring dislocations be substantiated? There are many questions yet to be answered in this interesting condition.

## SUMMARY

1 The operative findings in seventeen cases of recurrent dislocation of the shoulder are presented and discussed. Detachment of the glenoid labrum (thirteen cases) and the formation of a posterior humeral groove (eleven cases) were the most consistent findings.

2 In one case recurrent dislocation of the shoulder was due to avulsion of the subscapularis muscle.

3 The surgical treatment of these cases is described, usually consisting of a modification of Bankart's operation.

4 The results of follow-up are given as an intermediate report. No post-operative dislocation has so far been reported.

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## DISCUSSION

## on Recurrent Dislocation of the Shoulder

Mr A Bernard Pain (Leeds)—I have analysed the case records in hospitals of the Leeds area of patients treated by operation for recurrent dislocation of the shoulder during a fifteen-year period. Forty-five operations were performed on thirty-three patients (one bi-lateral seven operated upon twice, two operated upon three times). Twenty-six were males and seven were females. As to the cause the primary dislocation occurred eight times in football accidents and six times in epileptic fits; the other nineteen were due to falls of various types, in one instance the dislocation being due to suspension of the body by the limb concerned. These cases represent the work of my colleagues and myself, and sometimes of unknown surgeons whose previous operations have failed. Three were dealt with by simple division of the subscapularis and the operation was successful in two cases. One capsular reefing succeeded. The only Clairmont operation traced was unsuccessful. Of two Bankart operations one failed and the other succeeded. The majority of the traced cases fall into three groups—

*Henderson sling operation*. Of thirteen fascial or tendon sling operations there was recurrence in nine. It should be noted that recurrence of dislocation took place in every single case treated by slings of fascia lata and in four of seven cases treated by slings constructed from the peroneus longus. The Henderson sling operation is very disappointing. Of three cases operated upon for the second time—one by tendon sling for failure of a previous fascial sling, one by second fascial sling for failure of a previous fascial sling, and one by fascial sling for failure of a previous Nicola operation, the secondary operation failed in every case. Slings of fascia lata are to be condemned as being of no use and slings of transplanted tendon are very unreliable.

*Nicola operation*. Twelve Nicola operations were traced. One man had the operation performed on both shoulders ten years ago and there has been no recurrence since. In three cases there was recurrence within twelve months of operation, and in a fourth case, recurrence took place as long as seven years after operation. Thus the operation failed in one-third of the cases.

*Anterior bone block*. An iliac bone graft has been inserted near the edge of the glenoid cavity to provide an anterior bone block in four cases. These were treated in 1944, 1946 and 1947 and in no case has there yet been a redislocation. The number of cases is small but the procedure appears to be reliable. I wish to thank my colleagues in Leeds for permission to follow up their cases.

Mr A S Blundell Bankart (London)—The results of the operative treatment of recurrent dislocation of the shoulder can be stated very briefly. There is only one rational operation for this condition; it is applicable to every genuine case of anterior recurrent dislocation; it is almost foolproof and when it is properly done the patient is cured—the dislocation never recurs and the patient rapidly regains full use of his arm. I have no figures but I have probably done this operation more often than anyone else.

for I have been doing it for thirty years and I have never had a case in which the dislocation has recurred nor one in which there was serious limitation of movement after it

There are few operations of which it can be said that they never fail, but there are reasons why this operation should not fail. In the first place there is a constant anatomical lesion. It is not a matter of opinion; it is there for anyone to see who will take the trouble to look for it, and it has been seen by everyone who has looked for it. Secondly, no one who has seen this lesion exposed at operation could have any doubt as to what is the right thing to do with it. The capsule or the fibrocartilage is torn from the bone and the obvious thing to do is to put it back again. Thirdly, when I say that the operation is almost foolproof, I do not mean that fools should practise surgery, but that any surgeon of ordinary competence is capable of fixing a piece of fibrous tissue to a bone when both are exposed to view and accessible and it is difficult to see how he could fail.

There are certain technical points to be considered. First, the bone must be prepared for it, because soft parts will not adhere to unbroken or healed bone. By the same token any means of fixation is only temporary; no one can unite living tissues permanently by artificial means. All that the surgeon can do is to ensure that the parts are held together until they have united. In this operation union is complete in six weeks or less, after which the fixing agent has done its work and might just as well not be there. Indeed, the less there is of it the better.

For the actual fixation one may use sutures, nails, screws, staples, or anything. Nails and screws are makeshifts. I used staples twenty years ago, but gave them up because they were unreliable and clumsy. I believe that a single mattress suture of silkworm gut passed through the margin of the glenoid and the edge of the capsule is the simplest, the neatest, and the best. My only regret is that I did not discover the dental drill for this purpose until my second paper was in print. I have used the dental drill for nine years and it has solved completely the only difficult part of this operation.

I know that there are other operations which may prevent recurrent dislocation of the shoulder. But when we have a safe and certain cure by an operation which practically restores the joint to its normal condition and does the least possible damage to the surrounding parts, it seems extraordinary that anyone should go out of his way deliberately to create entirely artificial and abnormal conditions, such as slings, ligaments, tendon fixations, and bone blocks, in an endeavour to achieve the same result by roundabout means.

Some surgeons think that practically all operations for this condition depend for their success upon the formation of a mass of fibrous tissue in front of the joint—fibrosis of the anterior capsule and tying-down of the subscapularis. Indeed, some of the operations described seem to be designed to inflict the maximum amount of damage upon these parts, and for the same reason most of them are followed by considerable limitation of the normal movements of the joint. This is not true of my operation. Here the subscapularis is divided cleanly about half an inch from its insertion and it is allowed to retract inwards while the joint lesion is being dealt with, after which it is neatly sutured in place again. It is not "tied-down," shortened, or damaged in any way.

Abnormal laxity of the capsule is the oldest conception of the pathology of recurrent dislocation and it was responsible for all the reefing, plication, and overlapping operations which proved so unreliable in the past. It is quite unnecessary to introduce such complications into the operation to-day. The only abnormal laxity which is encountered is due to the fact that the capsule is detached from the glenoid margin, so that it can be pushed forwards by the head of the humerus when dislocation occurs. This defect is remedied when the capsule is attached to the bone and dislocation cannot then occur.

It may be that in the past I have laid too much stress upon the role of the fibrocartilage or glenoid labrum. This may be torn from the bone, or the capsule may be torn from it. In the latter case the surgeon will find that the labrum is intact and he may not realise that the lesion has occurred immediately external to it. In my operation this is of no importance, for in every case the capsule is incised over the glenoid margin and any part internal to this (including the labrum) is excised. The outer cut edge of the capsule is then attached to the raw bone. This disposes of any laxity of the capsule and it invariably prevents recurrence of the dislocation.

Defects in the head of the humerus probably occur quite frequently. They are due to the trauma of repeated dislocations and thus they are the consequences and not the causes of recurrent dislocation. I have seldom seen them because I have not looked for them. No good can accrue to the patient from an extensive dissection to expose such defects; nothing can be done about them if they are found, and there is no evidence that they ever interfere with the normal functions of the joint. Defect or no defect, the head of the humerus cannot get on to the anterior margin of the glenoid if the capsule is firmly attached to the margin.

A few cases have been reported in which redislocation is said to have occurred after my operation. In such cases it will be found that the operation has not been done as I described it, and in some of them an entirely different procedure has been carried out.

**Mr Newman (London)**—I have assisted Mr Bankart in many of these operations but when I did them myself I found them much more difficult than I had thought. The difficulty is to pull the head of the humerus laterally far enough to see the front of the glenoid. The solution is the Bankart skid, put through the joint so that the head of the humerus is levered away. The drill holes can then be made easily and the operation is simple.

**Mr Osmond-Clarke (London)**—in reply. Mr Bankart has made a devastating attack. We looked forward to it eagerly. One thing I must ask him to do—and his colleagues. We want to hear what number of cases have passed through the Middlesex Hospital and what number of lesions of the glenoid labrum have been seen. Surgeons have been looking for this lesion, and although they may often find it they fail to find it in ten or fifteen per cent of cases. These are reputable surgeons. Some operation must be devised for the cases in which there is no detachment of the labrum to be stitched back.

I have assisted Mr Bankart myself and I have watched many surgeons since—distinguished, mildly distinguished, and undistinguished. I have seen every conceivable form of trauma applied to the anterior margin of the glenoid and I have seen a surgeon after operating for one hour, faced with total disappearance of the bone surface he has been trying to drill.

For these two reasons I urge the claims of an easier repair which provides a sufficient block in front of the joint and at the same time limits external rotation movement so that the bone defect in the head of the humerus cannot engage the glenoid margin.

**Mr George Perkins (President)**—The only thing I want to say is that it has been a great pleasure to find younger contributors *speaking* to us and not *reading* their script. We expect that from a doddering old professor like Nobby Clarke but it is good to see more youthful members presenting their work so well.

# NOTE ON RECURRENT DISLOCATION OF THE SHOULDER JOINT

## Superior Approach Causing the Only Failure in Fifty-two Operations for Repair of the Labrum and Capsule

REGINALD WATSON-JONES, LONDON, ENGLAND

The clinical records of seventy-one patients on whom I have operated for recurrent dislocation of the shoulder joint have been re-examined. They may be analysed as follows

	Cases	Recurrences
Fascial sling operation (Henderson)	1	1
Transplantation of biceps tendon (Heymanowitsch, Nicola)	18	5
Labrum repair and capsular reefing (Bankart, Putti, Platt)	52	1

**Fascial sling operation**—The single case of fascial slinging, performed many years ago by the Henderson technique, may be dismissed, the operation is known to be unreliable and it has long since been abandoned.

**Transplantation of biceps tendon**—The Nicola operation with its various modifications has also been abandoned for more than five years. In this particular series the failed cases were shown at secondary operation to have sustained rupture of the transplanted tendon. This is by no means true of all failures of the Nicola transplant. The operation may fail for a number of reasons, and notably because the biceps tendon is often so placed that the humeral head can rotate around it and dislocate without so much as a strain being thrown upon the tendon. The explanation of the constancy of tendon rupture in this series possibly lies in the fact that the humerus was always drilled while it was held in the position of full internal rotation, and the direction of the drill hole was so planned that the tendon served as a check to external rotation movement which has long been recognised as the exciting cause of recurrent dislocation. Such check may explain the success of the operation in a proportion of patients, particularly those who are prepared to lead a sedentary life. But in this series of young athletic men it failed in one-third of the cases. Whatever the cause of failure, whether through misplacement of the tendon, or through rupture of the tendon because it is unequal to the task, the operation fails far too often.

**Repair of glenoid labrum with reefing of capsule**—The particular purpose of this note is to record fifty-two operations in which the glenoid labrum was exposed. In fifty-one operations an anterior exposure was used. If the labrum was detached it was resutured, in any event the anterior capsule was plicated and the subscapularis shortened, and all fifty-one operations succeeded in preventing recurrence. In one operation a superior exposure was used: an extensively detached labrum was securely stitched to bone, but the anterior capsule and subscapularis were never divided, indeed they were never exposed, they were not reefed or shortened, and the operation failed, dislocation recurring within six months.

In each of the fifty-one cases Bankart's exposure was followed in every detail—the deltoid and pectoralis major were separated, the coracoid process osteotomised, the coracobrachialis and biceps retracted downwards, the subscapularis divided and retracted inwards, and the capsule divided to expose the glenoid margin. In thirty-six of the fifty-one cases (70 per cent) there was a definite lesion of the labrum, ranging from separation in its lower part to bucket-handle displacement across the joint. In seven cases it was recorded at the time of operation that "there was a doubtful lesion," and in eight cases there was no lesion at all. Damage to the head of the humerus varied from simple bruising of articular cartilage in the postero-lateral sector, through every stage of "osteochondritis dissecans" to excavation of as much as one-third of the bone.

When the labrum was detached it was repaired by the Bankart technique. When the capsule was detached from the labrum, the labrum was usually resected and the capsule



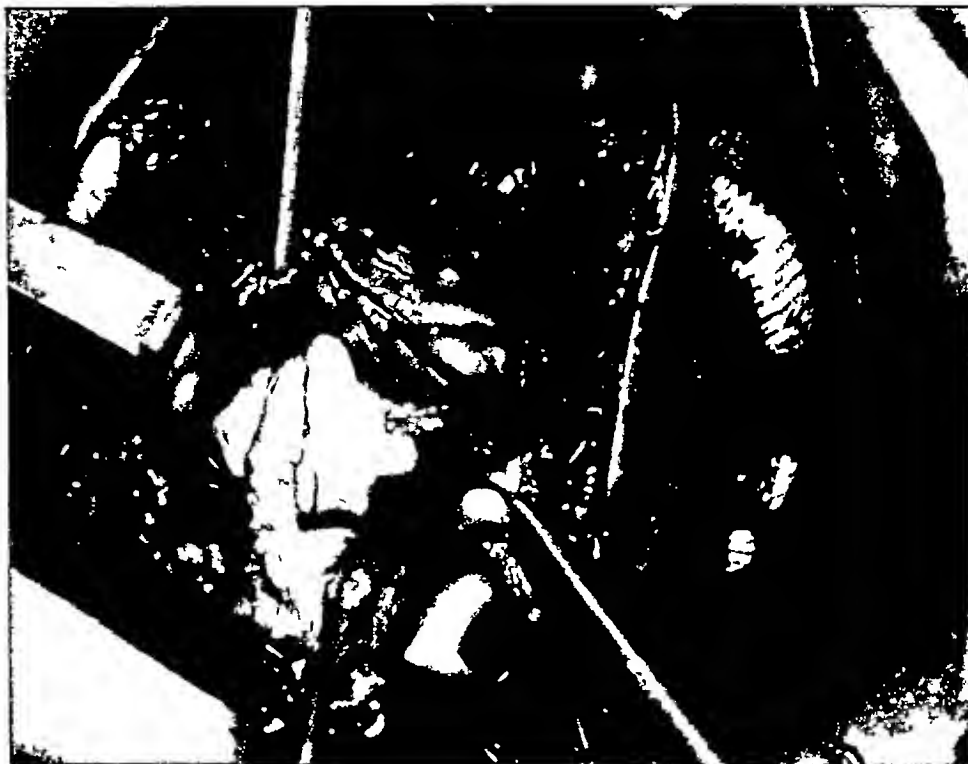


FIG 1

Recurrent dislocation of right shoulder joint exposed by superior approach showing  
 1) transplanted biceps tendon which is intact, but is not controlling external rotation  
 movement or preventing redislocation 2) large defect in the postero-lateral sector of  
 the head of the humerus

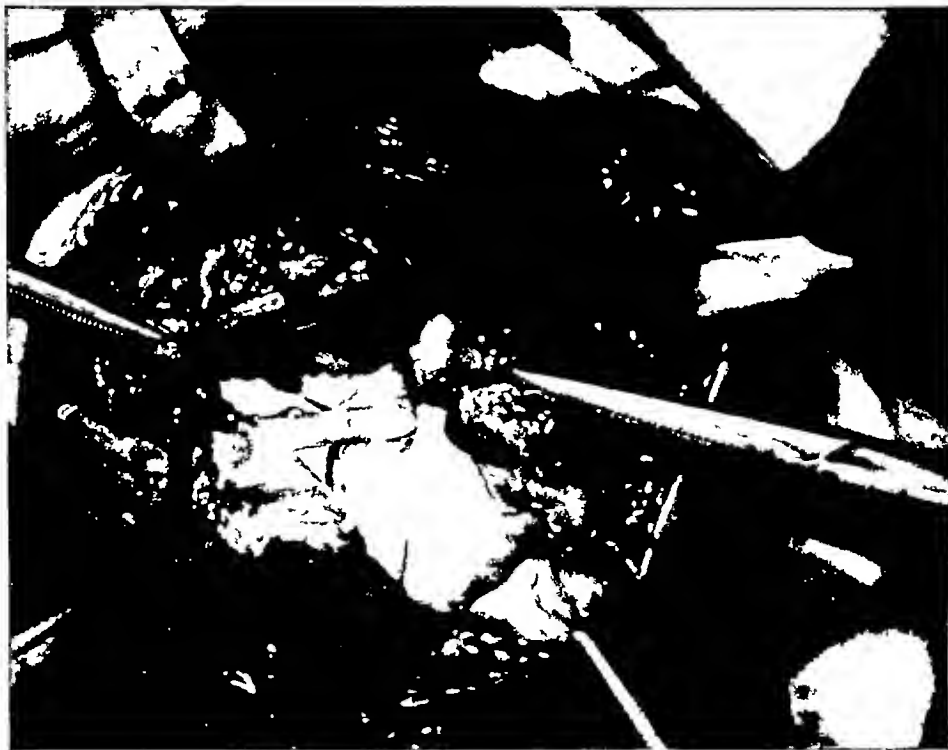


FIG 2

When the head of the humerus was pulled outwards and backwards an unusually clear  
 view of the anterior glenoid margin was gained. The widely detached labrum and  
 capsule are being lifted by an elevator to show the large pocket into which the defective  
 head of the humerus could subluxate

sutured to bone. But in every case, whether or not there was a labral defect capable of repair, the wound was closed with overlapping and double-breasting of capsule and slight shortening of the subscapularis by stitching it to a more distal insertion in the humerus—the procedure formerly known as capsulorrhaphy, and now described in a slightly modified form as the Putti-Platt operation. All these cases were successful, and so far as is known there has been no recurrence.

The one case which is particularly instructive is shown in Figs 1-3. For a number of reasons it was decided to expose the joint by means of a superior approach. The operation note, dictated by W. McKecknie who at that time was my first assistant, reads as follows:



FIG. 3

With the head of the humerus still retracted outwards and backwards two strong sutures have been inserted through the anterior glenoid margin and the detached labrum and capsule. The sutures are ready for tying.

**Operation, November 15, 1945**—Sabre blade approach to right shoulder by four-inch incision centred on the acromioclavicular joint. Osteotomy of base of the acromion which was reflected outwards together with the clavicular origin of the deltoid. Longitudinal incision in the line of fibres of the musculo-tendinous cuff with dissection of the anterior flap from the front of the tuberosity to expose the humeral head and glenoid from above. This revealed (a) a large deficiency in the posterior aspect of the humeral head well rounded and covered with fibro cartilage (b) tendon of the biceps previously transplanted by Nicol's operation performed elsewhere passing to the head of the humerus with no solution of continuity; it was quite loose and in no way held the head of the humerus or prevented it dislocating; in fact the proximal glenoid attachment was increasing displacement of the labrum by pulling it across the joint like a bucket-handle tear of a knee joint cartilage (c) complete detachment of the glenoid labrum from bone (d) a large pocket in front of the glenoid measuring two inches in diameter. The front of the neck of the scapula and the glenoid margin were freshened with an osteotome. Double holes were drilled and the labrum and capsule were securely stitched to bone by strong nylon and silkworm sutures.

*Observations at the time of operation*—(1) As an operative exposure this would seem to have many advantages over the anterior approach (a) there is less muscle splitting and division (b) there is no disturbance of the coracoid and its attached muscles (c) there is minimal splitting of the deltoid (d) there is a complete picture of the inside of the shoulder joint so that the humeral head, displaced labrum and glenoid are all seen much more easily than by the anterior exposure.



FIG 4

When there is a large bone defect in the head of the humerus it is not enough to repair the labrial defect. External rotation movement must also be controlled in order to prevent engagement of the defective part of the humerus with the anterior glenoid margin.

(2) Sutures through the glenoid labrum and capsule are fixed with much greater ease and certainty, and with more complete visual control than in the case of the anterior approach in which sutures are placed with some difficulty and uncertainty.

(3) We can now test from this case whether part of the required technique is fibrosis of the anterior capsule and tying down of the subscapularis which has often been accredited in Bankart's operation.

The final words of McKecknie's operation-note are worthy of repetition. As the subsequent history showed, we were indeed in a position to test "whether part of the required technique is fibrosis of the anterior capsule and tying-down of the subscapularis." The labrial defect was repaired in this patient with even greater certainty than any other of the fifty-two cases. Yet in this case alone dislocation recurred within six months. In this case alone the anterior capsule had not been divided, reefed, double-breasted, or fibrosed. In this case alone the subscapularis had not been shortened or "tied-down." Despite the ease of exposure, and the facility of repair, the superior approach is clearly a mistake. It deals successfully with labrial detachments, but it fails to give sufficient control of external rotation movement to meet the problem of defects in the humeral head. The inference is obvious. *Bankart's operation succeeds not alone by virtue of the repair of labrial lesions, but even more by virtue of the operative exposure of such lesions, and the subsequent resuture which limits external rotation movement.* Bankart made a great contribution to surgery by relentlessly, bluntly and forcefully directing attention to the anterior margin of the gleno-humeral joint, but his success in the treatment of recurrent dislocation of the shoulder joint lies more in the operative exposure he advocated than in the "essential lesion" he described.

**Summary**—Fifty-two cases of exposure of the glenoid labrum are recorded. Fifty-one operations with anterior exposure, followed by capsular reefing and shortening of the subscapularis, were successful. One operation with superior exposure, and without capsular reefing or shortening of the subscapularis, was unsuccessful.

# THE BONE BLOCK METHOD FOR RECURRENT DISLOCATION OF THE SHOULDER JOINT

IVAR PALMER AND ANDERS WIDÉN, STOCKHOLM, SWEDEN

*From the Surgical Service Södersjukhuset Stockholm (Surgeon-in-Chief Ivar Palmer)*

In 1918 Hybbinette, the Swedish surgeon, described a method of preventing recurrent dislocation of the shoulder joint by means of a bone graft fixed in a periosteal pocket at the anterior glenoid rim. At about the same time, Eden of Germany wrote on a similar method. Consequently the method came to be known as the Hybbinette-Eden operation.

Hoping to find the "essential lesion" Hybbinette explored the anterior part of the joint by dividing the subscapular tendon. He depicted his observation as a capsular injury resembling a "Gothic arch" with the denuded glenoid rim or detached labrum at its base, resulting in the formation of a false joint cavity into which the head would dislocate.

Eventually, the method was adopted widely in Scandinavia. Various workers who published papers on the subject (Dahlgren 1936, Langenskiöld 1932, Hublin 1946) agreed with Hybbinette's theory of a false joint cavity in the anterior part of the joint.

**Operative technique**—The Hybbinette-Eden operation is not difficult. A three-inch incision is made along the furrow between the deltoid and the pectoralis major. The coracobrachialis muscle is retracted medially and the lesser tuberosity, with the attachment of the subscapularis, is exposed by rotating the arm outwards. The tendon, together with the underlying capsule, is divided about a quarter of an inch from its insertion. The joint is held open with a retractor, and the humerus is pulled backwards and outwards. It is then possible to inspect the glenoid and anterior joint capsule from the inside. A subperiosteal pocket is made with a raspator at the lower part of the anterior glenoid rim. If there are remnants of the glenoid labrum the pocket is made between the rim and labrum, so that the labrum with attached capsule forms the medial border (Fig 1a). A graft, measuring about one inch by half an inch according to the size of the pocket, is taken from the iliac crest. The shape of the graft may be seen in the inset of Fig 1.

The graft is pressed down in the subperiosteal pocket in such a way that the projecting part is lodged on the rim, forming an anterior wall of bone. It is kept in position by remnants of the labrum and the periosteum. Additional fixation is not usually necessary (Fig 3).

The subscapularis tendon is stitched with mattress sutures, and the wound is closed. The arm is put in a sling for two weeks, the patient is then encouraged to move it, but always avoiding outward rotation. The patient is usually allowed up in two or three days.

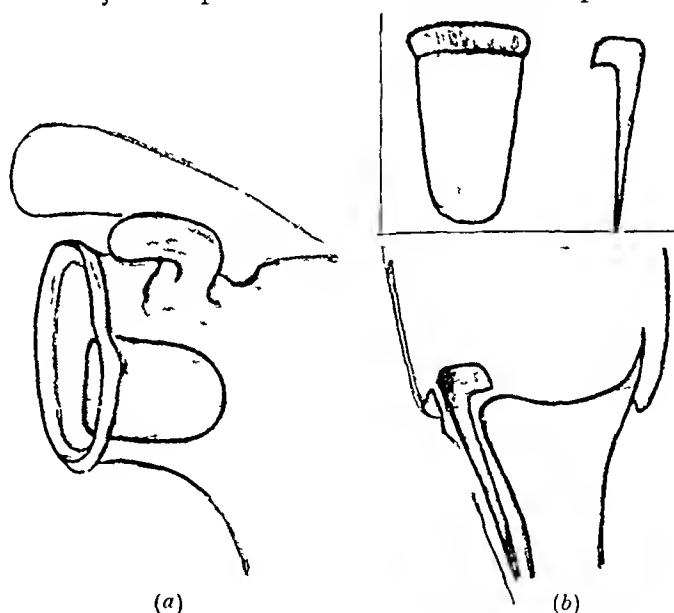


FIG 1

Inset shows the size and shape of the graft from the iliac crest. In the diagram the graft is shown in position in a periosteal pocket at the anterior glenoid rim. (a) from in front (b) from above. Note that a remnant of the detached labrum contributes to fix the graft.

and discharged in seven to ten days. We would draw attention to the fact that this method offers a shorter and more agreeable post-operative treatment than other methods now in use.

For the purposes of this paper, sixty cases, selected at random from our total of ninety cases, have been subjected to detailed study.

**Radiographic findings**—All cases were examined radiographically before operation. In each one a typical compression fracture in the posterior part of the head could be seen. In twelve there was a fracture of the glenoid rim forming a small semilunar fragment. In three, the examination was supplemented by arthrography. (For the technique of arthrography of the shoulder joint, the reader is referred to Lindblom and Palmer, 1939.) In none of these cases could abnormalities in the shape of the joint be observed. No capsular ruptures or accessible false joint cavities could be seen, nor was any rupture of the aponeuroses ever found (Fig. 5).

**Pathological findings at operation**—At operation the interest of the surgeon was, of course, concentrated on the anterior glenoid rim and its surroundings. First it should be pointed out, that in no case was it possible to find any false joint cavity or rupture of the capsule large enough to receive the humeral head. It is not easy to estimate the real volume of the capsular cavity by arthrotomy, because even a normal capsule is big enough to receive two humeral heads. For that reason we consider it impossible to make reliable observations by operation as to the volume of the capsular cavity. Arthrography is a better method for that purpose.

In twenty-seven cases we found typical detachment of the labrum from the anterior aspect of the glenoid rim (Fig. 2*a*). This detachment was in most cases located at the inferior part of the rim, thereby determining the situation for the pocket and the graft.

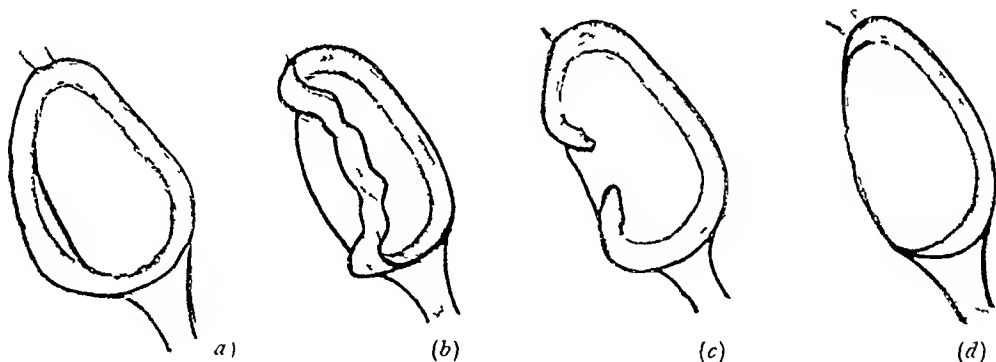


FIG. 2

Studies of different types of destruction at the anterior glenoid rim

- (a) The most simple lesion—a partly detached labrum
- (b) the detached labrum dislocated into the joint
- (c) the labrum ruptured and the rim worn
- (d) the labrum absent over the whole anterior rim sloping down towards the neck

In two cases the labrum was detached from the rim and from the capsule over the whole anterior aspect and dislocated into the joint, crossing the glenoid (Fig. 2*b*). The situation resembled a bucket-handle lesion of the semilunar cartilage of the knee joint.

In twenty-two cases the labrum was either ruptured with frayed flaps or else quite absent from the lower anterior part of the rim (Figs. 2*c* and *d*). In most of these the rim was smooth and rounded, and the bone was bare on the front of the neck of the scapular. It was then difficult to construct a pocket with a medial border strong enough to fix the graft in position.

In five cases there were only small changes on the edge of the labrum and in four cases it was not possible to find any pathological abnormality at all on the anterior rim. In these cases, too, radiographic examination had shown the typical compression fracture of the humeral head.

## RESULTS OF BONE BLOCK OPERATION

Our observations are based on material consisting of ninety operations, about half of which were performed by one of us (Palmer). We have been able to conduct follow-up examinations on sixty patients, eight of them women and fifty-two men. The preponderance of men in our series is due to the fact that part of the material originated in a military hospital. The interval between operation and follow-up varied from one and a half to twelve years.

**Complications — Limitation of movement**—No serious post-operative complications occurred. The results can be regarded as excellent in fifty-three cases, these patients consider themselves to be completely cured. Forty-two patients have a normal range of movement in the shoulder which was operated upon. Eleven report slight restriction of movement, usually in the form of 10 to 20 degrees limitation in abduction-elevation of the limb, accompanied in a few cases by insignificant limitation of external rotation movement. These patients, most of whom are young men, and many of whom are engaged in heavy manual labour, do not consider themselves handicapped in any way by this restriction. Many patients state that after operation they were able to resume various recreations and sports including football, handball, wrestling, tennis, and gymnastics.

**Pain**—In connection with the follow-up, most patients spontaneously expressed their great satisfaction with the result. In three cases there was not only slight restriction of movement but also pain on exertion. These symptoms were mild, however, they did not hamper the patients in their work, and the results may still be considered good.

**Recurrent dislocation**—Four patients (6.7 per cent) suffered further dislocation after the operation.

**Case 1** A man twenty-three years of age had thirteen dislocations before operation which was done in 1937. About one year after operation he again injured the right shoulder while playing handball. He had the arm held straight out from his side in an attempt to stop another player from running past him and as a result it was shoved violently backwards. The shoulder dislocated. The patient was able to reduce the dislocation himself. Since then he has had six dislocations for two of which he had to seek medical attention.

**Case 2** A man twenty-two years of age had five dislocations before operation which was done in 1942. At follow-up in November 1946 the patient was free from symptoms and had no recurrence. Two weeks later he informed us that he had fallen downstairs and dislocated the shoulder again. His wife reduced the dislocation. Since then he has had no further recurrence and has been at work as usual.

**Case 3** A man aged twenty years had four dislocations before the operation which took place in March 1942. In November 1942 while holding a horse by the bridle the horse tossed its head jerking the patient's arm upwards and dislocating the shoulder. After that he had many recurrent dislocations. A second bone block operation was done in October 1943. The old graft could be seen as a small bulge at the lower rim of the glenoid cavity. A new bone graft was inserted adjacent to the old one.

**Case 4** A man eighteen years of age had four dislocations before the operation which was done in 1944. One year later he fell with the arm abducted. The shoulder dislocated again and there have been five recurrences since then. A second operation was done in March 1947.

It is questionable whether these four cases should be considered recurrences in the true sense of the word. In all of them the first dislocation after operation was caused by an injury.



FIG 3

Radiograph showing graft in the correct position at the anterior rim forming an obstacle to the head

which might have caused dislocation in a previously undamaged shoulder joint. Nevertheless, estimation of the violence of injury must inevitably be subjective and unreliable. It is therefore wise to regard all post-operative dislocations as recurrences when comparing the results of different operative methods.

The following Table covers three series of bone block operations performed in Scandinavia

	Number of cases	Recurrences
Dahlgren	38	2
Hublin	30	2
Palmer-Widen	60	4
Totals	128	8=6.3%

### DISCUSSION

As already mentioned, there are usually two pathological findings in recurrent dislocation—a compression fracture of the posterior part of the humeral head, and an injury of varying size and shape on the anterior part of the glenoid. The former is evidently always present, but we want to call attention to the fact that the latter may be slight or entirely absent. In no case was it possible to find a "false joint cavity", nor was anything of that kind revealed by arthrography in three cases. Gustav Pettersson (1942) studied thirty cases of recurrent dislocation by arthrography without any pathological findings.



FIG 4



FIG 5

Typical radiograph of recurrent dislocation of the shoulder (Fig 4) with posterior compression fracture of the humeral head. The same joint shown by arthrography (Fig 5) displays no false joint cavity or rupture of the capsule. The joint looks normal.

It seems that Hybbinette, and many surgeons with him, interpreted a normal anatomical structure as a pathological condition. The subscapular bursa and the subscapular recess—possibly enlarged—may give the picture of a "Gothic arch" or "false joint cavity," bordered as it is by the gleno-humeral ligaments. Neither Hybbinette nor any of his followers realised the importance of the second lesion—the compression fracture of the head.

Bankart (1923, 1938) speaks of detachment from the anterior glenoid rim as *the essential lesion*. We are not sure that it deserves this name. The anterior lesion varies greatly, and it may be entirely lacking, so that it cannot explain the tendency of the head to dislocate. We consider that the mechanism of recurrent dislocation is as follows.

When the arm is more or less elevated, and the humeral head rotates outwards, the

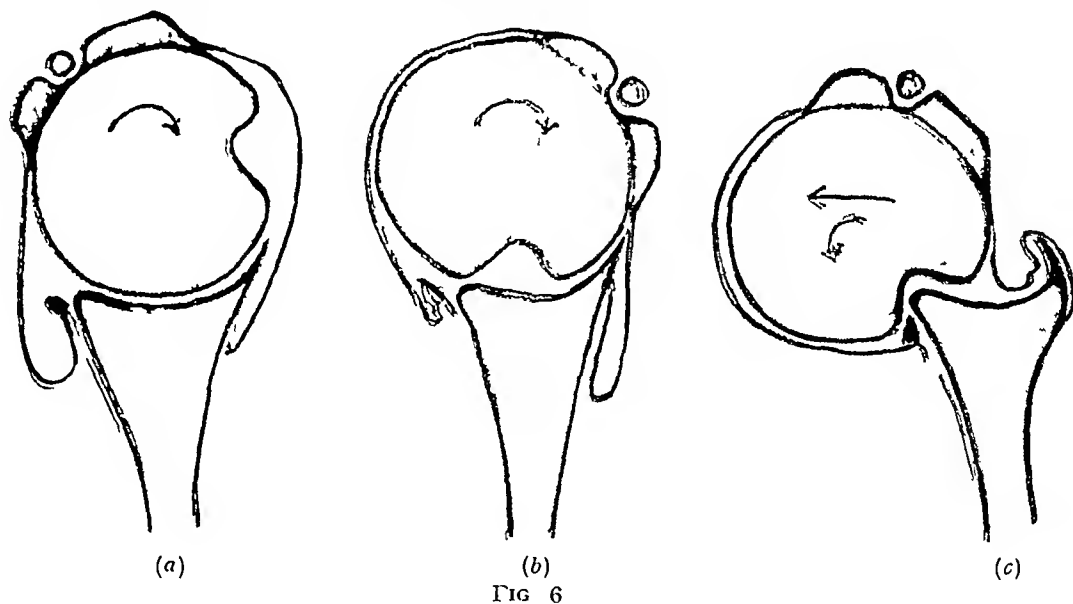


FIG 6  
Diagrams showing the relationship of the head of the humerus to the glenoid during outward rotation movement

- (a) The movement begins from the mid-position
- (b) compression is in front of the glenoid the articular surfaces have lost normal congruity and the joint is unstable
- (c) the rim of the glenoid slips into the furrow of the humeral head and the joint is subluxated in the typical manner

compression fracture in the posterior part first faces the glenoid cavity. Normally the cavity and head are entirely congruent in every position and the labrum adheres tightly to the head (Fig 6a). This gives a certain stability to the joint, which is not to be disregarded (Aeby (1876) and Johannes Muller (1929) called attention to the significance of atmospheric pressure in the stability of a joint.)

When the compression cavity turns towards the glenoid, the surfaces lose their congruity, the adhering force between head and cavity is lost, and the joint becomes unstable (Fig 6b). Next, the anterior rim slides into its hollow in the head of the humerus (Fig 6c). At the same time the head slides forwards, and only strong anterior support would be able to prevent dislocation *which in reality is not a dislocation at all, but a subluxation*. Parts of the joint surfaces are still in contact (the rim with the hollow), and the head never really dislocates through a capsular rupture or into a false joint cavity, as many seem to believe.

It thus appears that the essential lesion is not the variable anterior destruction of the joint margin but the deformity of the humeral head. Consequently the most logical treatment would be to reconstruct the head by filling in the compression hollow, it is probable that the tendency to dislocation would then disappear. For technical reasons this is not practicable, and we must therefore concentrate on the lesion at the anterior

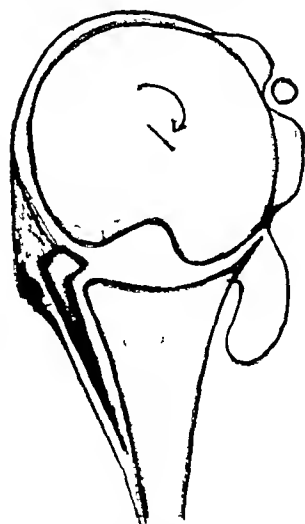


FIG 7  
Diagram to show how bone block and reactive tissues round it prevent the head from sliding round the corner in full external rotation of the humerus



rim Even if we cannot find damage here, reinforcement of the anterior support to the head will cure the condition

Hybbinette and Eden proceeded from false premises They did not realise the importance of the posterior compression hollow in the head, but believed in a false joint cavity into which the head dislocated Nevertheless, their anterior bone block method is excellent The graft forms an obstacle which stops the head from sliding forward, thus preventing it from sliding round the corner of the anterior glenoid rim (Fig 7) Reactive tissue around the graft forms a strong reinforcement of the anterior capsule, making a reliable anterior support for the head

If, as sometimes happens, the labrum is absent and the worn glenoid rim slopes down towards the neck of the scapula, it is difficult to achieve secure fixation of the graft For these cases there is probably no reliable method

### SUMMARY

The purpose of this paper is to call attention to the anterior bone block method of Hybbinette-Eden for recurrent dislocation of the shoulder joint

1 The operative technique is not difficult, and the after-treatment is short and relatively agreeable for the patient

2 Sixty of our own cases are described, with four recurrences The recurrences all occurred as the result of real trauma In a total of 128 Scandinavian cases there were eight recurrences—that is 6·3 per cent

3 In our opinion, based on the observations of radiography, arthrography, and operation, it is the compression fracture of the head of the humerus which deserves the name "essential lesion" Destruction of the anterior rim of the glenoid may be very slight, or entirely lacking No false joint cavity or rupture big enough to receive the head of the humerus was ever observed by arthrography or by inspection during operative exploration

*Recurrent dislocation is an intracapsular subluxation, which occurs when the anterior rim of the glenoid slides into the hollow in the humeral head*

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# EVOLUTION OF MOULD ARTHROPLASTY OF THE HIP JOINT

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*Moynihan Lecture delivered in the University of Leeds May 1947*

Mr Dean and Members of the Faculty of Medicine I am deeply appreciative of the honour of addressing you to-day as the fourth Moynihan Lecturer I am particularly happy because this invitation implies recognition of the specialty of orthopaedic surgery I am very grateful that you have chosen me as a representative of my specialty to give this lecture

Arthroplasty is an operative procedure undertaken for the purpose of creating a joint Such a joint, if it is going to stand up under the wear and tear of function, must be mechanically as nearly perfect as possible Until recent years this procedure as applied to the hip joint has met with limited success There were three main reasons

- 1 Surgical approaches were traumatic and inadequate, surgical shock commonly occurred even before the joint was exposed (Fig 1)
- 2 The joint created was defective because of lack of the proper instruments (Fig 1)
- 3 The underlying principle, of interposing a perishable barrier between imperfectly shaped joint surfaces, was not sound (Fig 2)



FIG 1

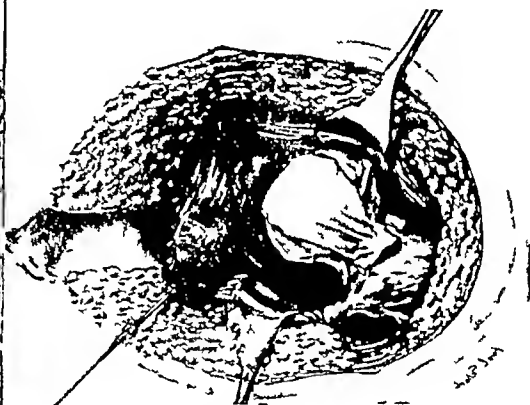


FIG 2

Dr William S Baer was one of the outstanding orthopaedic surgeons of his time He contributed much to the advancement of arthroplasty of the hip The above illustrations are copied from lantern slides in his collection made available through the kindness of Dr George E Bennett Fig 1 clearly demonstrates inadequate exposure of the acetabulum making it impossible to reconstruct this side of the joint It is interesting to note the carpenter's gouge with wooden handle

Fig 2 shows the imperfectly shaped femoral head covered by a perishable barrier

## DEVELOPMENT OF THE SURGICAL APPROACH TO THE HIP FOR ARTHROPLASTY

The teachings of Dr Harvey Cushing—respect for structures and structural planes—were directly responsible for a new approach to the hip joint After finishing my surgical internship at the Peter Bent Brigham, I started orthopaedic internship at the Massachusetts General Hospital in January 1916 In the spring of that year I assisted in an open reduction of a congenital dislocation of the hip The hip was exposed through a Kocher incision, it was bloody, it was brutal The patient survived by a very narrow margin Being used to the technique of Dr Cushing I was shocked and I said to my senior, Dr Roy Abbott, "There must be some other way of exposing the hip" "Why don't you figure one out?" was his answer That night, frontal bone flaps, approach to the pituitary, temporal decompression, exposure of the cerebellum, kept passing through my mind In all of them, when the periosteum was reached it was cleanly incised, its edges were carefully elevated, and it was reflected intact, always as a continuous structure and never in shreds

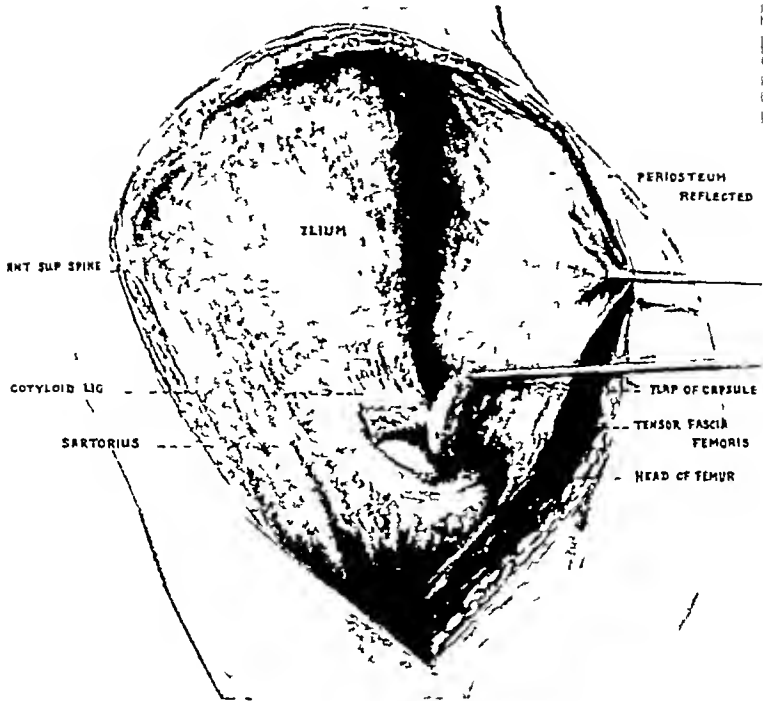


FIG 3

Supra-articular subperiosteal approach to the hip as published in 1917—a poor misleading illustration drawn from the anatomical specimen. Reflection of the periosteum was never carried out as extensively as shown. Even this approach gave inadequate exposure of the acetabulum.

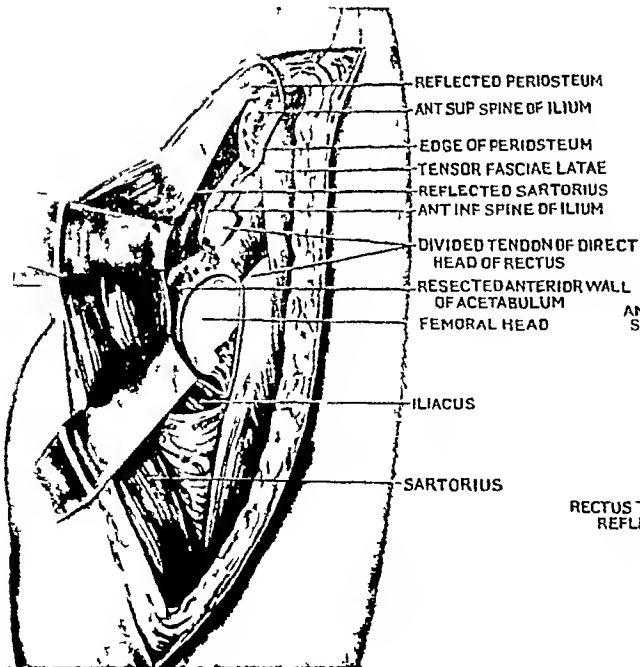


FIG 4

Exposure of the hip for acetabuloplasty as published in 1935. A mistake was made in saving a stump of the tendon of the rectus muscle and the anterior inferior iliac spine. By this approach the acetabulum was made accessible for reconstruction.

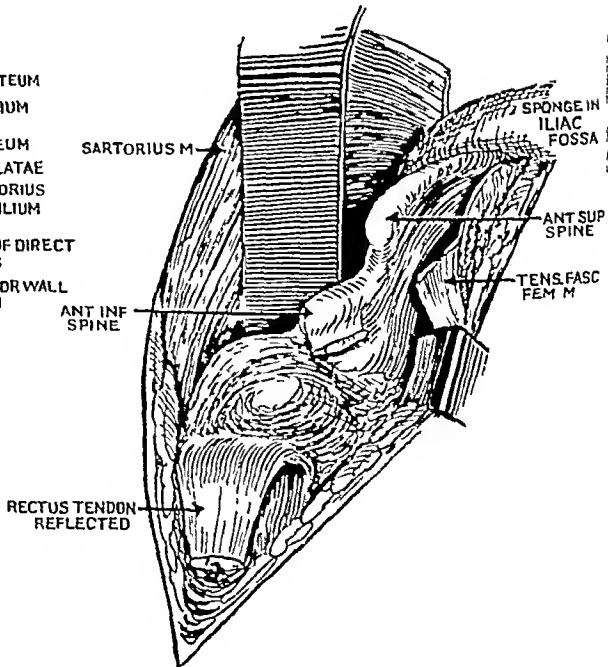


FIG 5

Exposure of the hip for mould arthroplasty as published in 1939. Mistake still being made of saving stump of rectus tendon and the anterior inferior spine. This resulted in calcification and spur formation requiring revision of the primary operation in several cases.

The cerebellum exposure, by reflection of muscle flaps with their periosteal attachments, was probably the one that gave me the idea of combining the anterior hip approach with the periosteal reflection of muscles from the lateral aspect of the ilium.

The next day I went to the Medical School and asked my old friend, Tom Bonney, for a hip. He gave me a nice lean one. I can still see it (Fig 3). It did not take long to demonstrate to my own satisfaction that the approach had merit, but would older and experienced surgeons feel the same way about it? I brought the specimen back to hospital and carefully hid it in the plaster-room under Ward 1. At the first opportunity I told the visiting surgeon that I thought I had a new way of exposing the hip joint. He laughed heartily and said "I like the enthusiasm of youth, if there were a better way of getting

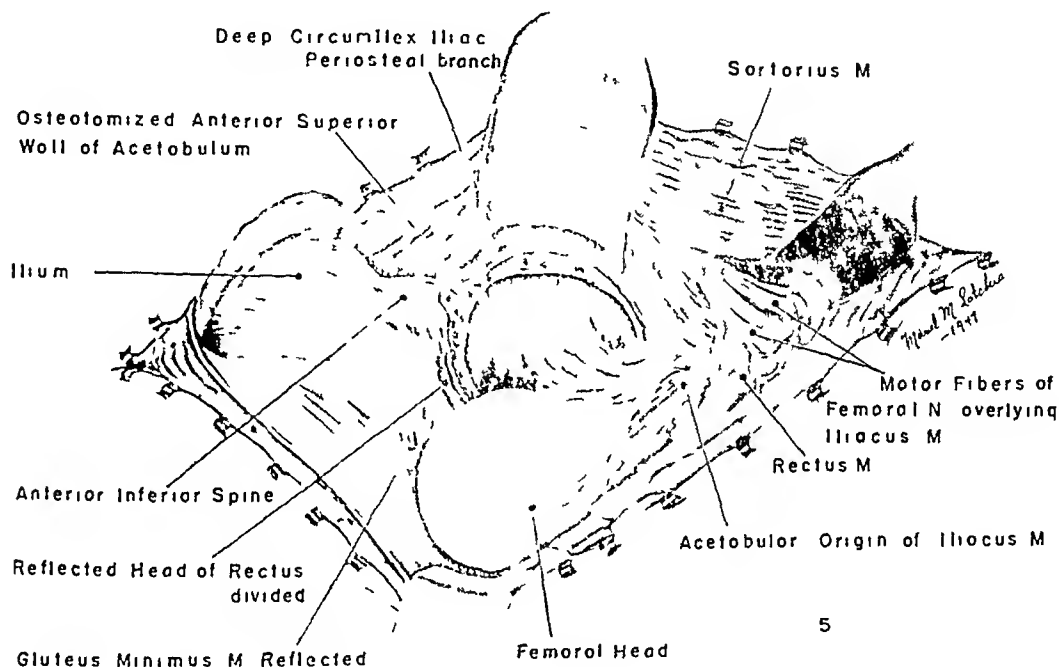


FIG 6

Exposure of the hip for mould arthroplasty as it is now done. It differs from the exposure of 1939 in two ways. 1 The direct head of the rectus muscle is divided at its attachment to the anterior inferior iliac spine and reflected laterally without being dissected out of its sheath. 2 The inferior half of the anterior inferior iliac spine is sacrificed.

Drawings of operative procedures are often misleading and make the surgeon feel that's easy. This drawing shows the femoral head markedly displaced and gives the impression that the posterior rim of the acetabulum is within the field of vision. This is seldom possible.

The periosteum is represented as an unbroken shiny sheet. It is possible to elevate the periosteum in this manner in young patients but in older patients the periosteum becomes thin and friable and it is impossible to lift it off the ilium as a continuous structure. Care should always be exercised in elevating the periosteum; it should never be scraped off the ilium.

The motor fibres of the femoral nerve are a little out of proportion to the surrounding structures. These fibres should always be exposed at least partly otherwise they are easily injured.

into the hip joint, don't you think that generations of surgeons who have gone before you would have discovered it a long time ago?" This was not exactly encouraging, so I did not invite him to see the specimen.

It was several days before the Chief of the Service, Dr Elliot G. Brackett, paid a visit to Ward 1. At the end of Rounds, I asked him if he would be interested in seeing a specimen which I thought demonstrated a new approach to the hip. "Why, certainly Doctor, of course I am," was his response. His reaction to the specimen itself was even more favourable. "You know Doctor, I think that approach has possibilities. Would you allow me to take the specimen with me? I am going to the American Orthopaedic Association Meeting tonight and I would like to demonstrate it." Returning from the meeting he reported a very

favourable reaction on the part of the older surgeons. In less than a year after this demonstration I had a nice letter from Dr Fred Albee telling me that he had used the approach on many occasions and that from then on he would use no other.

This supra-articular, subperiosteal approach to the hip improved the exposure of the head and neck of the femur, but the other side of the joint—the acetabulum—remained inaccessible. It was not until 1935 that this came within reach. "Acetabuloplasty"—excision of the anterior superior wall of the acetabulum—solved this problem (Fig 4). This operative procedure was developed in an attempt to relieve a patient with bilateral, intrapelvic protrusion of the acetabula. The attempt was successful and for a number of years this operation was used quite commonly. Because of the increasing success of complete mould arthroplasty, it is now seldom used. We do owe it credit for showing us the way to expose the anterior acetabulum by subperiosteal reflection of the sartorius and iliacus muscles from the ilium. We owe it credit for proving that the anterior acetabulum can be excised without joint instability resulting. We owe it credit for starting our thoughts in the right direction. The making of a joint demands reconstruction of both sides of the joint so that the surfaces will be congruous and work smoothly in relation to one another (Fig 5). The present exposure of the hip is extensive, but it is no more than adequate, and it is unaccompanied by shock because it respects structures and follows structural planes (Fig 6).

#### DEVELOPMENT OF INSTRUMENTS

A carpenter has a work-bench with its vice. He can adjust his stock to any position necessary for good workmanship. He has good tools—so good that many surgeons advocate their use in bone surgery. A surgeon has no work-bench and no vice in which he can adjust his stock. His instruments, therefore, must be designed to overcome this difficulty,

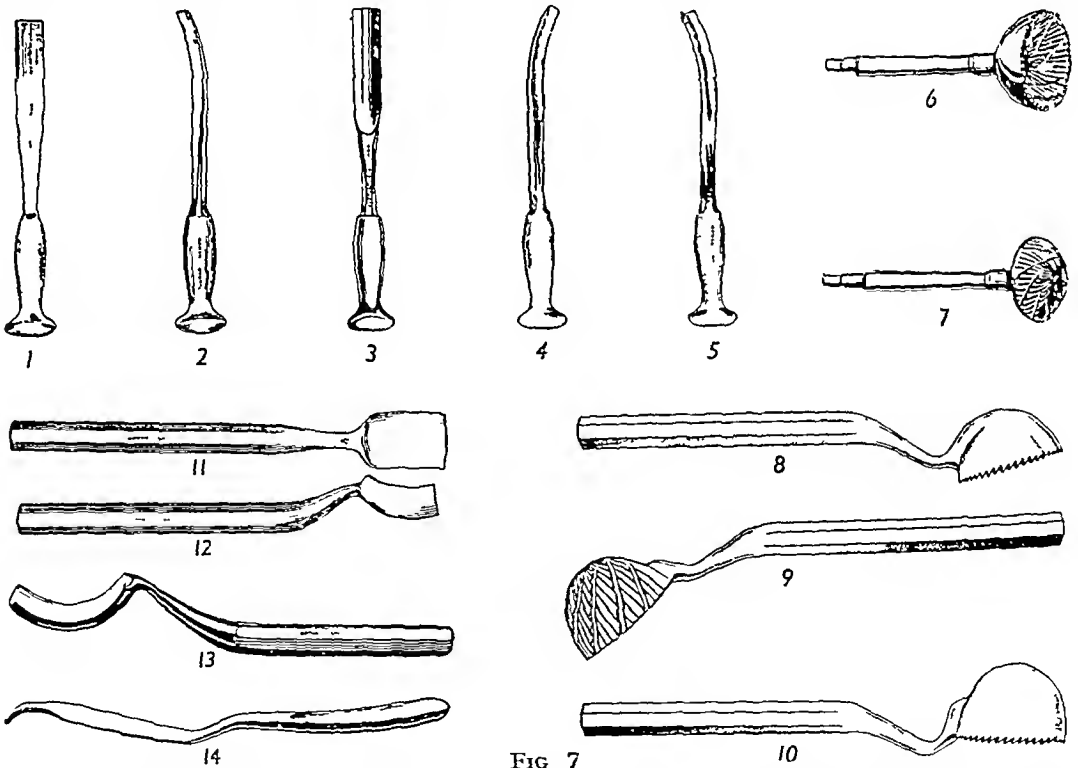


FIG 7

1 Thin straight osteotome four widths 2 Thin curved osteotome four widths 3 Thin straight gouges four widths 4 Thin curved gouges four widths with corresponding curves 5 Reversed gouge three widths with corresponding curves useful in undercutting acetabular margins 6 7 Female and male reamers for initial shaping of the femoral head and acetabulum 8 9 10 Eccentric female and male reamers for final shaping of femoral head and acetabulum making these surfaces congruous 11 12 Hip gouges first used in 1925 they have the same curves as the joint surfaces of a normal femoral head 13 Large gouge first used in 1944 same curves as the smaller hip gouges particularly useful in excising the posterior margin of the acetabulum

they must reach places out of sight cut away bone around the corner, and polish surfaces inaccessible to the rasp or file.

Gouges of various sizes with curves corresponding to the surfaces of a normal hip joint have been in use since 1925 (Fig 7). It is thrilling to watch them disappear from sight, knowing that if given the proper start they cannot go wrong.

Irregular, uneven surfaces do not make a joint fit to function. Special reamers, with the same curves as the gouges, have been designed for the purpose of making the new joint surfaces smooth and congruous. These again work in the dark, but they work safely and efficiently.

Many other instruments have been designed from time to time, each aiming to overcome some technical difficulty, so that we can now say we no longer miss the carpenter's bench or his vice.

### PRINCIPLE OF MOULD ARTHROPLASTY

The hip joint is a fulcrum exposed to the leverage of the strongest muscles in the body and to the trauma of weight-bearing. A joint exposed to such stresses with every step must indeed be mechanically perfect, almost without friction, if it is going to have lasting function. With this in mind it seems justifiable to say that any type of arthroplasty depending upon defective joint surfaces and the interposition of a perishable barrier is bound to have limited success. Fascia lata and similar perishable goods have been used for this purpose for almost forty years, and many satisfactory results have been reported by surgeons who have had extensive experience with this method. The percentage of failures, however, has been relatively high, and the functional results in terms of range of movement have been disappointing (Figs 10-11).

In 1923 a piece of glass was removed from a patient's back, it had been there for a year. It was surrounded by a minimal amount of fibrous tissue, lined by a glistening

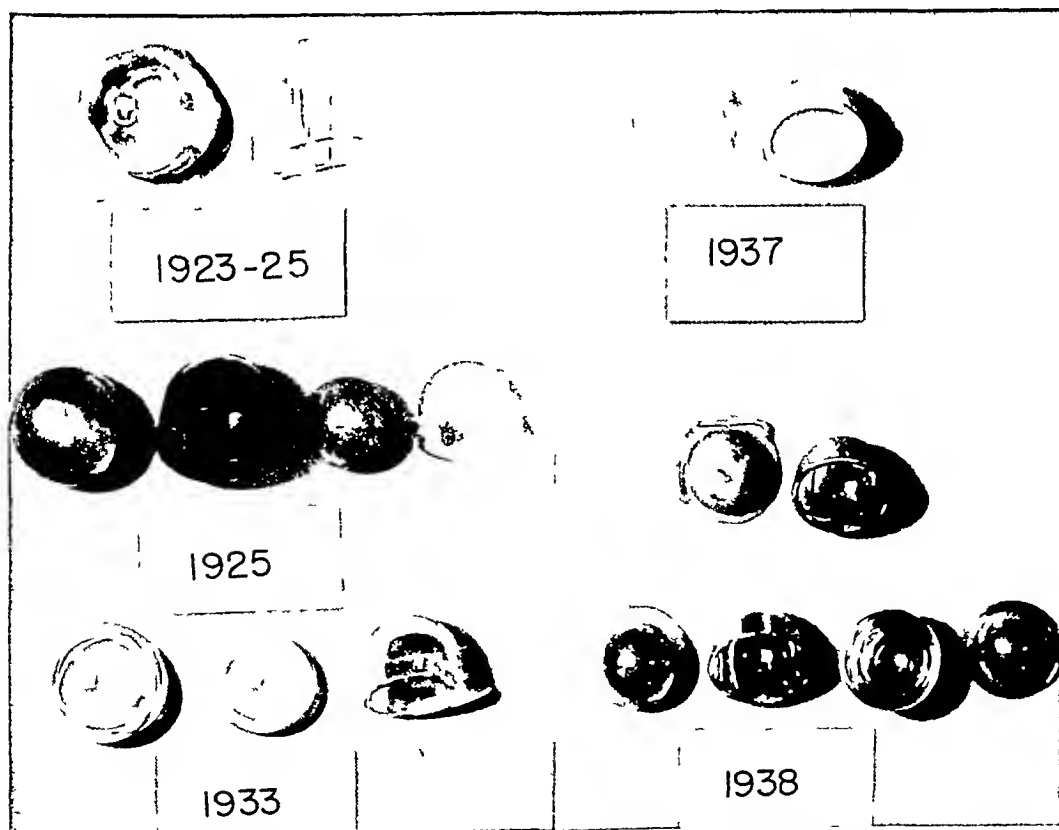


FIG 8

Evolution of moulds 1923—glass 1925—viscoid 1933—pyrex glass

FIG 9

Evolution of moulds 1937—bakelite 1938—unsuccessful and successful metal

synovial sac, containing a few drops of clear yellow fluid. This benign reaction to an inert foreign body gave rise to the thought that here was a process of repair which might be applied to arthroplasty. This first thought gradually developed and the idea of the "mould" was conceived. A mould of some inert material, interposed between the newly shaped surfaces of the head of the femur and the acetabulum, would guide nature's repair so that defects would be eliminated. Upon completion of repair the mould would be removed, leaving smooth, congruous surfaces mechanically suited for function (Figs 8-9).

Glass naturally suggested itself as the inert material from which moulds could be constructed. Macalister Bicknell of Cambridge, Massachusetts, who made the first X-ray tube for Dr Walter Dodd, made the first crude moulds. Looking back upon these moulds now, I am amazed that I had the courage to use them. The fact that I did illustrates the value of a professional family such as we have at the Massachusetts General Hospital. I needed someone to lean on. Who should it be? Dr C. Allen Porter was my choice. Time and again he sat down with me—answered questions, analysed doubts, and encouraged me to carry on.

The day after constructing the first glass mould arthroplasty I received a call to see Dr George Holmes in the old X-ray Department, the former accident room. "What are you up to now?" He was looking at two X-ray plates (not films) taken of the same patient.

"Here we have bony ankylosis of the hip and here, twenty-four hours later, we have what appears to be a joint lined by cartilage." I explained. George laughed and shook his head. "What will you be up to next?" This was in 1923.

Some of the glass moulds broke after having been in place a matter of months. This was a disheartening experience but it had one encouraging aspect. When the pieces were removed, the acetabulum and head of the femur were found to be covered by a firm, glistening lining. We had some evidence, then, that the principle of guiding nature's repair by means of a mould was sound. The original glass moulds were abandoned and the search went on for some other material, inert and strong enough to stand up under weight-bearing.

Viscoid, a form of celluloid, was tried first experimentally and later clinically, but



Successful arthroplasty maintaining 45 degrees of motion, 17 yrs. after operation. Painful osteoarthritic hip.

FIG 10

The arthroplasty in this case resulted in a mechanically imperfect joint. Such a joint does not improve with use; it deteriorates.



FIG 11

This film demonstrates an acetabulum which has not been reconstructed. Inadequate exposure and lack of proper instruments made this impossible. Confining the surgical procedure to the femoral head does not create a joint with lasting function.

it produced too much foreign body reaction and had to be given up. Eight years went by without success. In 1933 we went back to the use of glass, this time "pyrex." The moulds were considerably heavier and were tested under the polariscope for evidence of strain under compression. Theoretically they were strong enough but practically they were not. Some of them broke. Since we could not trust them, they were used only in selected cases and not on an extensive scale. The majority of these patients did well. When the moulds were removed after fifteen to twenty-five months the joint surfaces were smooth, glistening, firm, and congruous. Histological examination of specimens removed showed fibrocartilage around the periphery of the articular surfaces, and hyaline cartilage in the central portion (Fig. 12). Since the central portion is the part of the joint most exposed to the intermittent pressure and friction of weight-bearing, it seems reasonable to conclude that metaplasia from fibrocartilage to hyaline cartilage takes place in response to these physiological physical stresses. The principle involved in mould arthroplasty may be represented diagrammatically as follows:

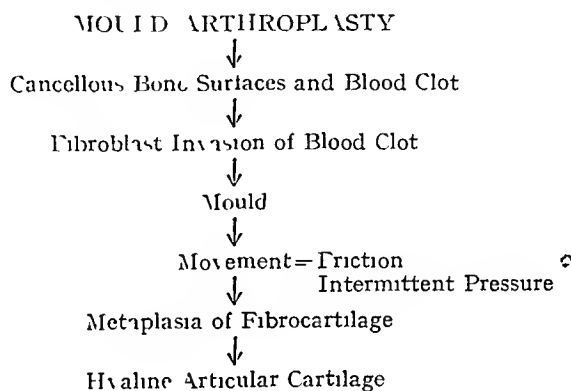


FIG. 12

Micro-photograph of specimen removed at operation twenty-five months after glass-mould arthroplasty. Hyaline cartilage. Homogeneous matrix and typical cartilage cells. Arrangement of cells less regular than in normal cartilage.





FIG 13

H F Typical case of malum coxae senilis in a patient seventy-four years old. Marked flexion adduction and external rotation deformity. Dependent upon medicine for sleep. Operation justified by patient's excellent physical condition.

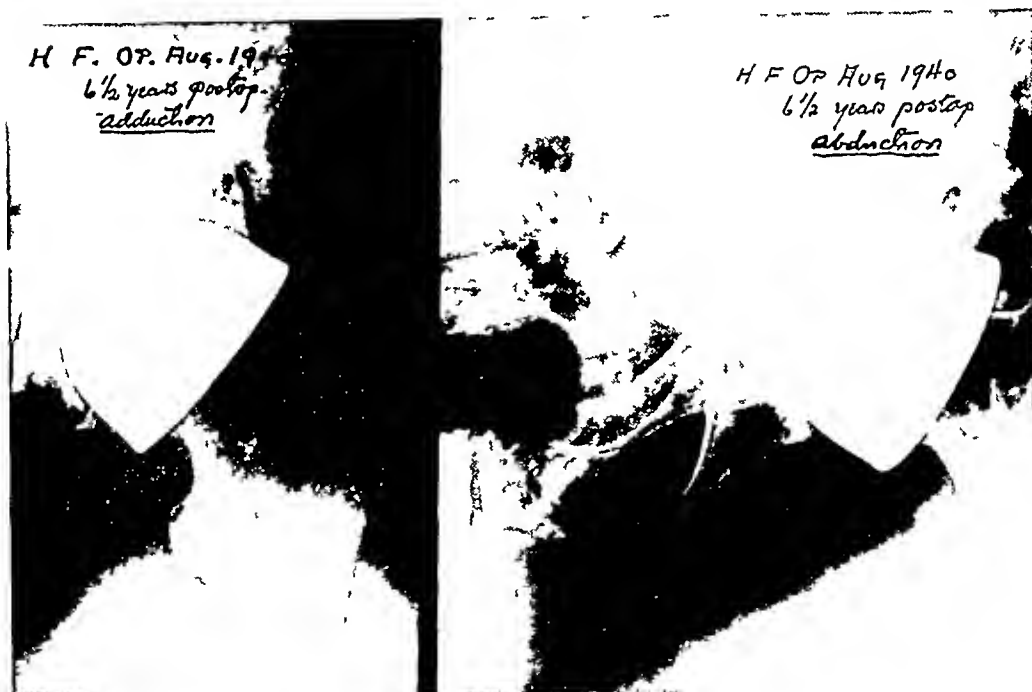


FIG 14

H F Same patient as in Fig 13 six and a half years after operation. Patient now eighty years old. No symptoms arising from the hip which has been operated upon. Walks without a limp. Range of movement better than on the opposite side. No flexion deformity. Movements—flexion to 120 degrees, internal rotation 15 degrees, abduction 25 degrees.

Criticisms. Marked proliferative bone changes on the lateral surface of the ilium. The surgeon may not have been sufficiently careful in elevating the periosteum. It is also possible that the post-operative dressing may not have been sufficiently snug to prevent oozing and resulting formation of a subperiosteal haematoma. The acetabulum was not made as deep as we now make it. In view of the excellent functional result we must point out that the depth of the acetabulum varies with the local conditions encountered. This case was selected because it is very instructive and the result of operation is extremely satisfactory.



FIG 15

B C Typical case of rheumatoid arthritis of ten years' duration in a thirty year old patient. Rigid flexed spine. 80 degrees flexion deformity of hips. 25 degrees flexion deformity of knees without evidence of active disease. Minimal involvement of shoulders and hands. Unable to walk except by supporting himself with hands on thighs and using a knee ankle gait. Bilateral hip arthroplasty performed early in 1940 enabling patient to get around with crutches. Osteotomy of third and fourth lumbar vertebrae in late 1941 allowing patient to stand erect. Not a favourable case for operation because of the advanced bone atrophy accompanied by loss of elasticity and atrophy of soft tissue structures.



FIG 16

B C Post-operative film of same patient as in Fig 15 a poor film but the best available. It is now seven years since the bilateral arthroplasty there is as yet no indication for revision of the primary procedure. Patient able to put on his shoes and stockings worked in a factory throughout the war. The large moulds are probably responsible for the relatively mild intrapelvic protrusion of the acetabula.

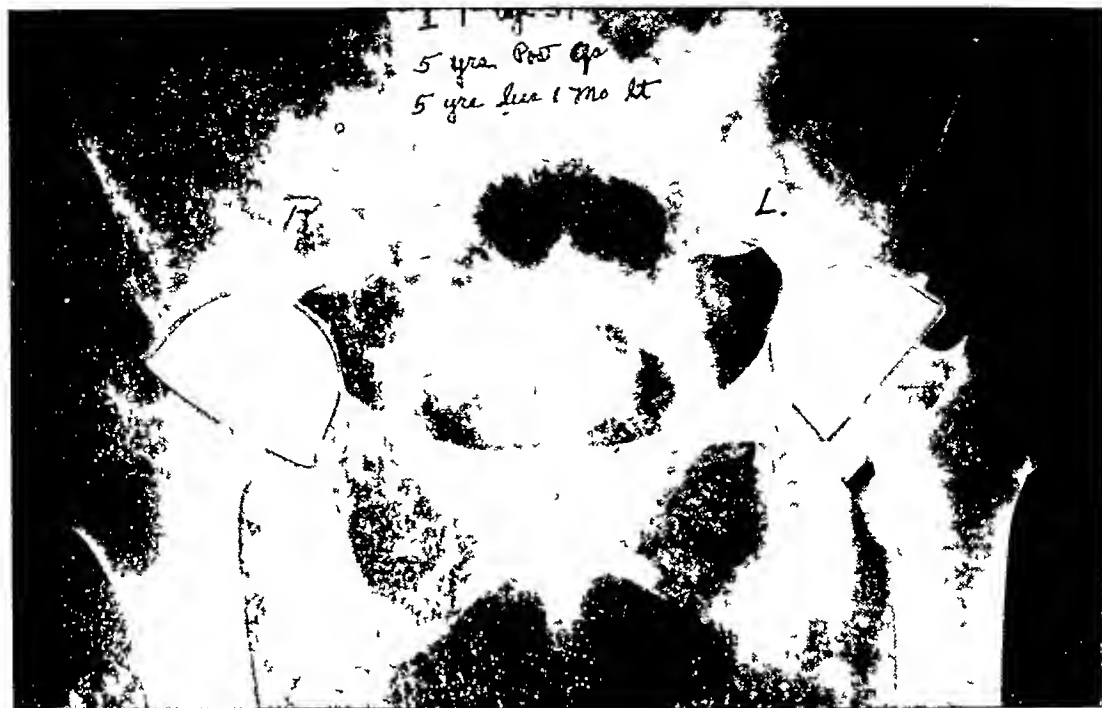


FIG 17

I T This patient was first operated upon for bilateral bony ankylosis of the hips at the age of thirty-two. She had a rigid spine and involvement of joints of the upper extremities. For five years after bilateral arthroplasties she was able to get around with the aid of crutches and was employed as a librarian. The range of movement became progressively less and it became increasingly difficult for her to sit comfortably. New bone formation and intrapelvic protrusion accounted for the loss of movement. Revision of the primary procedure was decided upon when the range of movement had been reduced to 30 to 40 degrees.

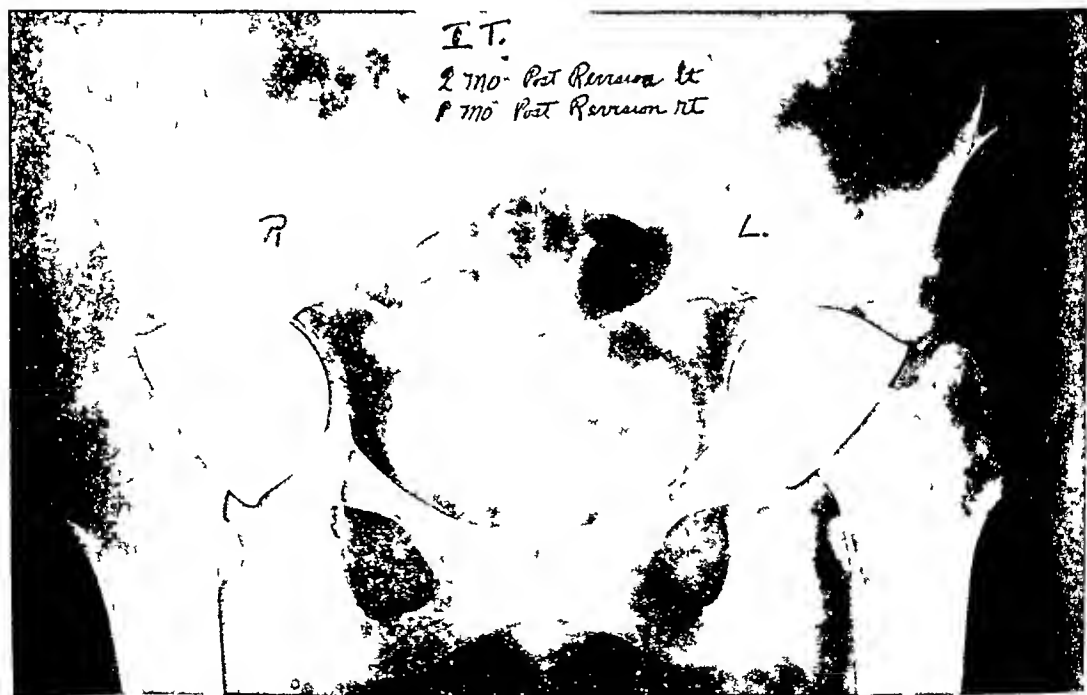


FIG 18

I T Same case as shown in Fig 17. Early post-revision X-rays. Radical excision of the superior and posterior acetabulum has been performed. Some of the floor of the acetabulum has been sacrificed. It is not yet possible to judge the final result but it is fair to say that the character of the bone at the time of revision had improved markedly from the soft atrophic bone at the time of the primary arthroplasty.



FIG 19

A F Typical case of aseptic necrosis of the femoral head following subcapital fracture of the neck. This patient had no internal fixation of her fracture. A mould arthroplasty was performed two years later because of increasing pain and disability.



FIG 20

A F Same case as in Fig 19 three years and seven months after mould arthroplasty. Patient now walks without a limp except when she is tired. She is self-supporting as a music teacher, and is independent of help for any purpose whatsoever.



FIG 21

H P A typical case resulting from too much internal fixation. Fractured hip treated by the internal fixation of wood screws. Both the head and neck of the femur have been absorbed to such an extent that they no longer cast a shadow by X-ray.

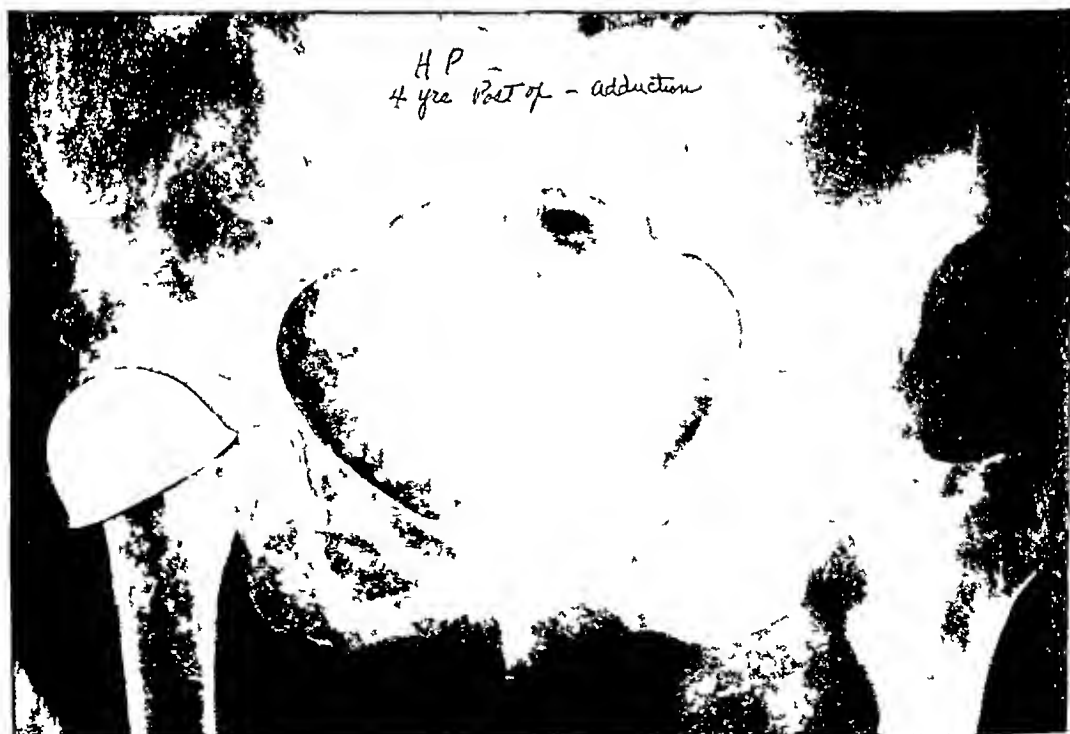


FIG 22

H P Same case as in Fig 21. Four years have elapsed after a modified Colonna operation. A mould has been placed over the greater trochanter. The ilium has been osteotomised vertically in order to extend the acetabular roof laterally. The lesser trochanter has been partly excised to prevent impingement on the posterior lip of the cotyloid notch. Patient is free from pain and has a range of movement more than sufficient for all purposes. Her hip is relatively weak; she uses a walking stick for long distances but never in the house.



FIG 23

R G Typical case of bilateral septic arthritis of the hip joints in early childhood. When first seen the patient was nineteen years old and just graduating from High School. She was suffering severe pain and found it extremely difficult to assume the sitting position for any length of time. This film shows extensive destruction of the hip joints with a varus relationship of the remnants of the head and neck to the shaft of the femur.



FIG 24

R G Same case as shown in Fig 23 a little over two years after bilateral ne On the right, the greater trochanter has been transplanted downwards in or mechanical interference. This was done as a secondary procedure some months after arthroplasty. On the left symptoms have not yet developed sufficiently to just procedure. There is evidence of benign repair in response to the mould. This patient do the work of a secretary and is relatively free from pain. The range of movement is not such that she is independent of the help of others. Further operative treatment unquestionably be necessary.

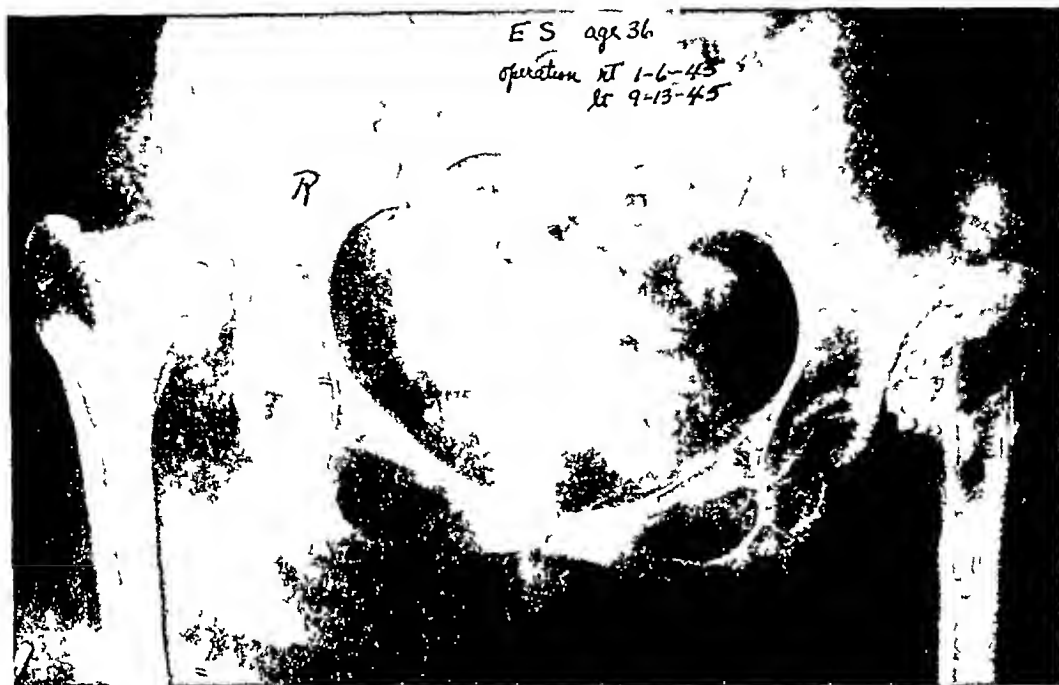


FIG 25

E S Bilateral dislocation of the hip joints in a woman of thirty-six. Trendelenburg markedly positive on both sides left more than right. Considerable pain arising from both hips and low back. Left hip presented a difficult problem because of the absence of the femoral neck.



FIG 26

E S Same patient as in Fig 25 post-operative film. The right hip was operated upon in January 1945. It was possible to create a new deep acetabulum at a level corresponding closely to the original acetabulum and to extend the acetabular roof laterally by vertical osteotomy of the ilium. By transplanting the femoral head from a lateral to a mesial position increased stability and improved muscular leverage was accomplished. At this time two years after operation the Trendelenburg sign is negative and the range of movement is sufficient for all purposes.

The left hip was operated upon eight months later September 1945. Between operations patient got around on crutches but had to wear a two-inch high sole on the left. The operation on the left was essentially the same as on the right, but it was necessary to transplant the trochanter downwards because of the absence of the femoral neck.

At this time one and a half years after operation the left hip has the same range of movement as the right but it is definitely a weaker hip. The Trendelenburg sign has been diminished but not eliminated. Because of this weakness on the left the patient still uses a walking stick on the right.

## REVIEW OF RESULTS

In 1937 my dentist, Dr John Cooke, suggested vitallium as the ideal material from which to make the moulds. After several unsuccessful attempts a satisfactory mould was obtained. In 1938 the first vitallium mould arthroplasty was performed. Since then over 500 hips have been operated upon by this method at the Massachusetts General Hospital, eighty of these were bilateral. The fact that we have been willing to perform this operation on such an extensive scale is evidence that the results have been satisfactory.

*Malum coxae senilis*—Eighty-four arthroplasties, six of them bilateral, making a total of ninety, have been performed. The results have been more satisfactory than those of arthrodesis. The range of movement obtained has usually been sufficient to enable the patient to put on shoes and stockings. Most of them have a limp but it is a pain-free limp which allows them to lead an active life (Figs 13-14).

*Rheumatoid arthritis*—Seventy-eight arthroplasties, forty-nine of them bilateral, making a total of 127, have been performed. It is fair to say that the results are at least encouraging. The range of movement is not as great as in malum coxae senilis and seldom sufficient to enable the patient to put on shoes and stockings. As a rule the patient's general activities are increased because of relief of pain, and many of them return to active, productive life. The frequent multiple joint involvement—spine, knees, and joints of the upper extremities—easily accounts for the less satisfactory results (Figs 15-18).

*Complications of fractured hips*—A total of fifty cases have been operated for non-union, aseptic necrosis, and dead heads. The results are very satisfactory and compare favourably with those obtained in malum coxae senilis (Figs 19-22).

*Old septic hips*—Twenty-four cases, eight of which were bilateral, making a total of thirty-two. The discouraging aspect in this group of cases is the post-operative flare of original sepsis. This occurred in eight cases. When this complication does not occur, the results are very satisfactory and the range of movement is better than that obtained in rheumatoid arthritis. This is probably due to the fact that patients in this group are able to be active, and consequently do not have the same degree of bone muscle atrophy, nor do they have limitation of movement of the knee joints (Figs 23-24).

*Congenital dislocations*—Forty cases, ten of them bilateral, making a total of fifty. The youngest patient was aged thirteen years, the oldest sixty years. The results are most satisfactory. The main reason for this success is probably the mesial transplantation of the femoral head into a new and deep acetabulum. This results in stability and improved muscular leverage so that the Trendelenburg sign is markedly diminished (Figs 25-26).

*Other conditions*—The operative procedure of mould arthroplasty has been applied to practically all conditions to which the hip joint is subject.

## SECONDARY REVISIONS OF THE FIRST ARTHROPLASTY

Fifty-three patients have been subjected to revisions of the first arthroplasty. These revisions have been necessary to a great extent because of errors in technique and judgment during the early development stages of the procedure.

*Revision for calcification of rectus tendon*—Leaving the proximal stump of the rectus tendon attached to the inferior iliac spine, so that the distal tendon could be resutured to it, was a mistake. In several cases the proximal stump became calcified, and interfered with the range of flexion movement. This difficulty has been overcome by dividing the rectus tendon close to the inferior spine, then suturing it at the end of the operation to the reflected head of the rectus, or to the tendon of the gluteus minimus.

*Revision for enlargement of acetabulum*—The need for a relatively large acetabulum was not fully appreciated at first. By enlarging the acetabulum mesially and inferiorly, more stable relationship for weight-transmission is obtained and the mould is less apt to catch on the posterior lip of the cotyloid notch.



*Revision in rheumatoid arthritis*—Many patients with rheumatoid arthritis have been operated upon a second time because of a decreasing range of movement. In most of these there was considerable bone and muscle atrophy at the time of the primary arthroplasty. Exercises aiming to overcome lack of elasticity of contracted structures and to restore muscle power forced the mould against the soft atrophic bone, bringing about gradual

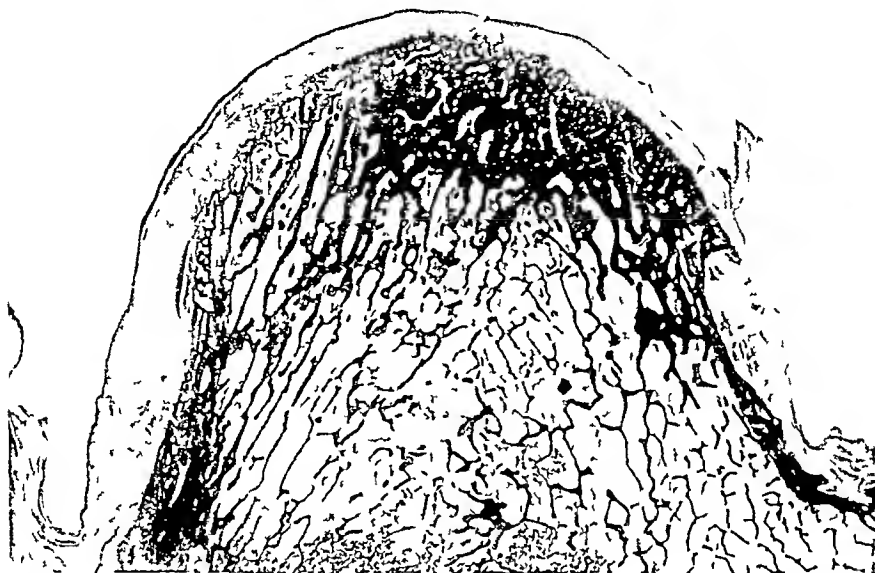


FIG 27

Section of femoral head removed at autopsy five years after glass-mould arthroplasty three years after replacement by a vitallium mould

deepening of the acetabulum. Intrapelvic protrusion of the acetabulum was not an uncommon result. Naturally this diminishes the range of movement but does not eliminate it. Even the limited function obtained in these patients brings about improvement in the character of the bone, so that secondary revision can be undertaken two or more years after the primary procedure under much more favourable conditions.

*Revision when first operation complicated by sepsis*—Operative sepsis has been responsible for a small number of revisions.

### COMPLICATIONS

*Post-operative sepsis*—Twenty cases, eight of these occurred in patients with old septic hips, and infection developed several weeks or months after operation. If we can interpret these cases as flares of the original infection, which seems legitimate, operative infection in 500 arthroplasty procedures is reduced to twelve. It is fair to say that, with the use of chemotherapy in one form or another, post-operative infections should be still further reduced. During the last year we have had no operative sepsis in more than fifty hip arthroplasties.

*Pulmonary embolism*—Pulmonary embolism has occurred, but never with fatal outcome. Vein ligation has been resorted to in a limited number of cases. In a series of sixty arthroplasties undertaken in complications of fractures of the neck of the femur, vein ligation was undertaken in one case.

*Mortality*—In this series of approximately 500 arthroplasties there has been no operative mortality.

## CONCLUSIONS

This is the first time that the principle of the mould—the principle of guiding the repair of nature for the purpose of recreating a destroyed or damaged structure, has been applied to surgery. The evolution of the method to its present encouraging stage is the result of the co-operative, professional family spirit of the Massachusetts General Hospital. We all share in it. We share it with the general surgeon because of his contributions to surgical technique. We share it with the “medical man” because of his pre-operative and post-operative care of the patient, because of his guidance as to when, and when not, to operate, and because of the many friendly arguments which are productive of so much good. We share it with the anaesthetist because of his clinical judgment of the patient, his selection of anaesthetic agent, and his continuous, conscientious administration of the anaesthetic throughout the operation.

I am going to change from “we” to “I”. I owe so much to my assistants, from the first to the last: Bill Rogers, Eddie Cave, George Van Gorder, Paul Norton, Milton Thompson, Otto Aufranc, and Carroll Larson. I want to thank them all for helping to carry the load, for remembering the things that I forgot, and for making helpful suggestions which often led to improvement in surgical technique or to the construction of a useful instrument. I want to pay tribute to the staff of the Orthopaedic Service of the Massachusetts General Hospital and to thank its members for kindly scepticism, constructive criticism, and never-failing loyal support.

The subject of this lecture, “Evolution of Mould Arthroplasty of the Hip Joint,” is appropriate for a Moynihan lecture. It is not the work of one man alone. It is the work of one man, supported by a co-operative, helpful, and friendly hospital staff. This is what Lord Moynihan strove so hard to bring about at a time when surgeons viewed one another as rivals. To quote Dr William Mayo: “It is to Lord Moynihan’s everlasting credit that, largely as a result of his unceasing efforts, surgeons came to consider themselves as fellow-workers in a cause.”

# POST-OPERATIVE STUDY OF VITALLIUM MOULD ARTHROPLASTY OF THE HIP JOINT

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During 1946 I had the privilege of working with Dr Smith-Petersen who made it possible for me to carry out a detailed study of vitallium mould arthroplasty of the hip joint. A total of 150 unselected cases was reviewed clinically and radiographically. An end-result study was made, taking into consideration the initial lesion of the hip joint, operative technique, post-operative course, and the value of the operation as judged by patient and surgeon. The cases may be grouped as follows:

Congenital dislocation of the hip joint	16 patients
Complications of femoral neck fracture	45 „
Infective arthritis of the hip joint	27 „
Rheumatoid and Marie-Strumpell arthritis	26 „
Traumatic arthritis of the hip joint	21 „
Malum coxae senilis	15 „

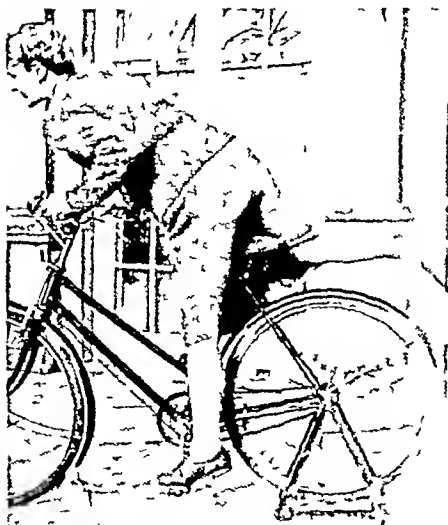
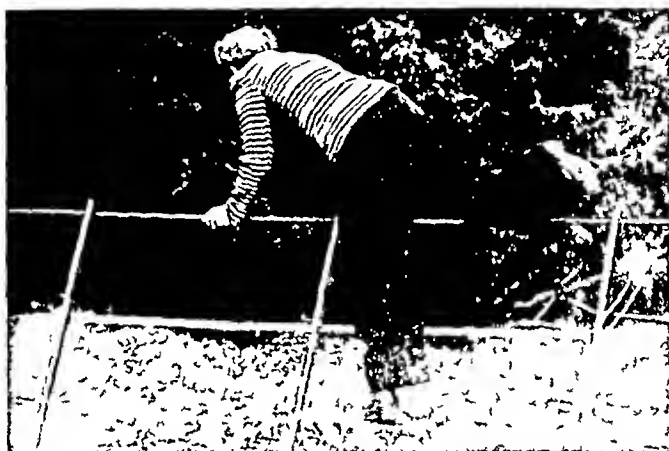
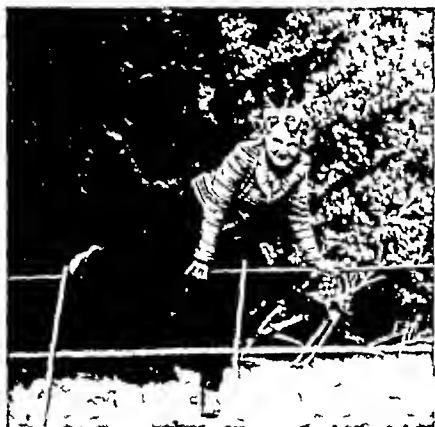
Rather more than half the patients were seen less than two years after operation so that they cannot, strictly speaking, be described as end-results, but they do have an important bearing on post-operative progress.

## REVIEW OF THE WHOLE SERIES OF 150 CASES

**Pain**—In uncomplicated cases pain was minimal during the early post-operative phase and also during the convalescent stage of treatment. At a still later stage there was no more than a sensation of stiffness when activity was first begun after a period of rest. Imperfect gait or the unaccustomed use and redevelopment of atrophied muscles may cause pain, particularly in the region of the greater trochanter and suprapatellar region, but this responds readily to treatment. Complications such as faulty relationship of the vitallium mould to the femoral head and acetabulum, recurrence of infective or degenerative arthritis, or lighting up of disease in rheumatoid arthritis, may result in pain in the hip region sufficiently severe to warrant operative revision of the arthroplasty. In these cases pain was accompanied by muscle spasm and diminution in the range of active and passive movement of the joint.

**Gait**—In the majority of patients distance walking is best supplemented by the use of a walking stick, even in the later stages. Some younger patients with good muscle power are the only exceptions.

**Range of movement**—Table I represents the whole series of 150 cases and indicates the average post-operative range of hip joint movement. It is seen that in cases examined during the first two years after operation the average range of flexion movement was less than 70 degrees, in the next two-year period the range increased to 75 degrees, and in cases examined four to six years after operation the average range was 80 degrees. In this table an attempt is made also to assess the value of the operation as judged by patient and surgeon. The low percentage of unsatisfactory results, and the still lower percentage of results considered unsatisfactory by the patient, is good evidence of the value of the procedure. Movement of the joint was smooth and free from pain, and with correct post-operative supervision it allowed the redevelopment of an elastic and well-balanced gait. This was achieved only if the patient co-operated to the fullest possible extent in carrying out exercises, and practising re-education of gait, during the first two post-operative years. Thirteen per cent of



Patient aged 56 years demonstrating function eight months after arthroplasty for malum coxae senilis. She reports that she walked with two sticks about two miles over rough turf and parkland including very steep inclines and concludes I can now trespass to my heart's delight

results were unsatisfactory to the patient, the surgeon was dissatisfied with 20 per cent, in other words 80 per cent of results showed adequate function. The proportion of unsatisfactory results was approximately the same in cases examined during the first two post-operative years, and in cases examined after a longer interval (Table I)

TABLE I

RANGE OF HIP JOINT MOVEMENT AND ESTIMATED VALUE OF VITALLIUM MOULD ARTHROPLASTY IN TOTAL SERIES OF 150 PATIENTS (182 ARTHROPLASTIES)

Years after operation	Average range of flexion	Condition of hip			
		Satisfactory to patient	Unsatisfactory to patient	Satisfactory to surgeon	Unsatisfactory to surgeon
0 - 2	68°	90	14	85	19
2 - 4	75°	42	3	37	8
4 - 6	80°	29	4	26	7

**Mortality**—The operative mortality rate for the whole series was nil. There was only one death, four months after operation, due to post-operative septic arthritis in a case of complication of femoral neck fracture.

**Complications**—The main complications were post-operative sepsis, subluxation of the vitallium mould, and bone proliferation with resulting impairment of joint movement (Table II). These conditions are readily dealt with by operative revision, though in cases of rheumatoid arthritis considerable difficulty arises and repeated operation may be necessary owing to the atrophic state of soft tissues, as well as of bones and joints. In spite of division of blood-vessels in the course of reflecting or excising the joint capsule, avascular necrosis within the mould was very uncommon. This is attributable to the method of refashioning congruous joint surfaces at the level of bleeding bone. In two cases only was revision required for too small or too large a mould, and in the latter cases a large mould had been used deliberately. Comparison of the range of movement and residual deformity in the various groups of hip joint disease treated by arthroplasty is shown in Table III. It will be noted that the least satisfactory results were in cases of infective and rheumatoid arthritis. These cases (with the exception of Neisserian infection) are to be described as poor "stock" for arthroplasty. On the other hand these patients benefit greatly by relief of pain, improvement in the degree of permanent deformity, and by the acquisition of even a small range of movement. The average shortening over the whole series of cases was a little over one inch, but in cases of old congenital dislocation of the hip joint the *gain* in leg length, or in bilateral cases the gain in height, was quite remarkable.

#### ARTHROPLASTY FOR CONGENITAL DISLOCATION OF THE HIP JOINT

In congenital dislocation of the hip joint single arthroplasty was performed in twelve patients and double arthroplasty in four. The average age at the time of operation was thirty-four and a half years. Three patients, having had mould arthroplasty on one side, are anxious to have the same reconstruction on the other hip joint. Post-operative dislocation occurred twice and was corrected satisfactorily by revision of the arthroplasty, increasing the depth of the acetabulum and transplanting the muscles inserted into the greater trochanter. In one of these cases there was such atrophy of the femoral head and neck that a modified Colonna operation was performed. Post-operative sepsis occurred once and this unsatisfactory result will be treated by revision of the arthroplasty when infection is quiescent. Revision was also required in one case in order to secure better relationship between the mould and the new joint surfaces, thus improving the range of movement. In one other

TABLE II  
COMPLICATIONS IN 182 ARTHROPLASTIES OF THE HIP

Lesion	Congenital hip 16 cases	Fracture com- plications 45 cases	Infective arthritis 27 cases	Rheumatoid arthritis 27 cases	Traumatic arthritis 21 cases	Malum coxae senilis 15 cases	Total
Superficial sepsis	—	2	3	2	1	—	8
Deep sepsis	1	4	1	2	—	1	9
Subluxation or faulty relationship	2	3	1	—	—	—	6
Avascular necrosis within the mould	1	1	1	—	—	—	3
Hypertrophic changes and loss of move- ment	1	2	2	9	3	1	18
Detached greater trochanter	—	1	—	—	—	—	1
Ganglion formation	1	—	1	—	—	—	2
Sciatic paralysis	—	—	1	—	—	—	1
Pleural effusion	—	—	—	—	1	—	1

TABLE III  
RANGE OF HIP JOINT MOVEMENT AND PERMANENT DEFORMITY IN  
182 ARTHROPLASTIES OF THE HIP (150 PATIENTS)

Hip Function	Congenital hip 16 patients 22 arthro- plasties	Fracture com- plication 45 patients 45 arthro- plasties	Infective arthritis 27 patients 34 arthro- plasties	Rheumatoid arthritis 26 patients, 42 arthro- plasties	Traumatic arthritis 21 patients 23 arthro- plasties	Malum coxae senilis 15 patients 16 arthro- plasties
1 Flexion—						
Over 100°	4	7	2	2	8	3
80°–100°	8	16	7	4	8	8
60°–80°	4	18	6	7	4	4
Under 60°	6	4	19	29	3	1
2 Rotation—						
Over 25°	11	16	9	4	10	4
15°–25°	7	18	6	6	10	4
Under 15°	4	11	19	32	3	8
3 Abduction Adduction—						
Over 25°	13	19	11	3	10	3
15°–25°	4	15	4	7	7	4
Under 15°	5	11	19	32	6	9
4 Shortening—						
Average	(4 gains)	1½	1½"	1"	¾"	1"
5 Flexion Deformity—						
Over 25°	5	—	8	14	3	—
10°–25°	1	9	5	13	3	1
0°–10°	—	9	3	7	3	2
None	16	27	18	8	14	13
6 Rotation Deformity—						
Over 15°	—	2	2	1	2	2
0°–15°	—	3	1	—	2	2
None	22	40	31	41	19	12
7 Adduction Deformity—						
Over 15°	—	—	—	1	—	—
None	22	45	34	41	23	16

case continued absorption of the femoral head within the mould necessitated revision Ganglion, or Baker's cyst formation, arising from the new joint capsule and presenting anteriorly, necessitated a second operation in one case Mucoid material was aspirated and the ganglion excised without entering the hip joint The range of movement which was acquired, the gain in leg length, the gain in height in bilateral cases (in one case over two inches), the improvement in gait, and the general improvement in posture, placed these cases among the most

TABLE IV  
CONGENITAL DISLOCATION OF THE HIP JOINT  
Follow-up Study of 16 Patients (20 Arthroplasties)  
Range of Movement and Estimation of Value of Operation

Years after operation	Average range of flexion	Condition of hip			
		Satisfactory to patient		Satisfactory to surgeon	
0 - 2	80°	5	1	5	1
2 - 3	86°	8	—	7	1
3 - 4	65°	1	—	1	—
4 - 5	100°	2	—	2	—
Over 5	62°	2	1	2	1

satisfactory results of treatment by arthroplasty The patients were of course relatively young they were capable of developing good musculature and thereby improving the functional result

#### ARTHROPLASTY FOR THE COMPLICATIONS OF FEMORAL NECK FRACTURES

Forty-two of the forty-five cases in this group were analysed in detail in a previous communication (Law, W A, 1947) In summary it may be said that the results resemble those in traumatic and degenerative arthritis, though it must be recognised that avascularity of the femoral head, or absorption of the femoral neck, may necessitate variation of the routine mould arthroplasty procedure and the use of a modified Whitman or Colonna reconstruction, or intertrochanteric mould arthroplasty Post-operative complications included infection (six cases), subluxation of the mould (three cases), avascular necrosis within the mould (one case) and hypertrophic changes at the mould margin (two cases) One patient died from septicaemia due to infective arthritis of the hip joint following arthroplasty four months previously In the whole series of forty-five cases the result was satisfactory, both to surgeon and patient, in thirty-five cases

#### ARTHROPLASTY FOR SEPTIC ARTHRITIS OF THE HIP JOINT

Arthroplasty should be attempted in septic arthritis of the hip joint only in the late and quiescent stage Even then there is danger of reactivation of the infective process The use of systemic and local penicillin, with or without one or more secondary revisions of the arthroplasty, has enabled satisfactory results to be obtained in a considerable number of cases, which is all the more satisfactory in view of the frequency of bilateral ankylosis In this series, twenty cases were unilateral and seven bilateral These patients form a young group, the average age being only twenty-nine years It is well-known that gonococcal arthritis responds well to treatment by arthroplasty and this is borne out clearly by four cases in the series Only four cases of septic arthritis treated by mould arthroplasty were complicated by post-operative infection, and only one failed to respond to revision with excision of the scar, the sinus, infected granulation tissue, and areas of osteitis in the vicinity of the mould This secondary operative treatment was supplemented by chemotherapy

Revision was also required in two cases complicated by bone overgrowth, in one case in which a ganglion had formed and there had been absorption under the mould due to continued activity of the disease, and in one case where too small a mould had been used. One other case was complicated by temporary sciatic paralysis due to stretching of the nerve in the course of reduction of a long-standing dislocation. The average range of hip movement, and the post-operative results, are shown in Table V. It will be seen that, on the average, the

TABLE V  
SEPTIC ARTHRITIS OF HIP JOINT  
Follow-up Study of 27 Patients (34 Arthroplasties)  
Range of Movement and Estimation of Value of Operation

Years after operation	Average range of flexion	Condition of hip			
		Satisfactory to patient	Unsatisfactory	Satisfactory to surgeon	Unsatisfactory
0 - 2	61°	20	4	19	5
2 - 3	66°	7	—	6	1
3 - 4	35°	—	1	—	1
4 - 5	—	—	—	—	—
Over 5	55°	—	2	—	2

range of movement is considerably less than in traumatic and non-infective cases. It is more comparable with, though slightly better than, the range of movement in cases of rheumatoid arthritis. Nevertheless, the great majority of these patients gained benefit from the operation. Most of them have been operated upon within the last three years, and it is early to judge the end-result. Moreover during this time new instruments have been devised and the technique has been improved. It is probable that review at a later date will show more satisfactory end-results. This probability gains support from the greater proportion of satisfactory results in the two to three-year follow-up as compared with the up to two-year review.

#### ARTHROPLASTY FOR RHEUMATOID ARTHRITIS OF THE HIP JOINT

In treating rheumatoid and Marie-Strumpell arthritis by mould arthroplasty, it must be recognised from the outset that after the primary operation one or more operative revisions may be necessary. The first mould insertion makes it possible to stretch taut and contracted tissues, to redevelop wasted muscles, and to construct the elements of a new joint.

TABLE VI  
RHEUMATOID ARTHRITIS OF HIP  
Follow-up Study of 26 Patients (42 Arthroplasties)  
Range of Movement and Estimation of Value of Operation

Years after operation	Average range of flexion	Condition of hip			
		Satisfactory to patient	Unsatisfactory	Satisfactory to surgeon	Unsatisfactory
0 - 2	44°	26	4	23	7
2 - 3	47°	2	—	1	1
3 - 4	62°	5	—	5	—
4 - 5	43°	2	—	1	1
Over 5	88°	3	—	3	—

Secondary operations are often needed for the remodelling of joint surfaces and the correction of subluxation or faulty relationship of the femoral head, mould, and acetabulum. Though the end-results in these cases are less perfect, and the range of hip movement less satisfactory, than in the non-infective groups of cases, the fact is that many completely bedridden



individuals have been able to walk with crutches, to sit comfortably, and thus to lead a relatively normal life and even earn a living

Bilateral mould arthroplasty was performed in sixteen cases and unilateral arthroplasty in ten patients. The average age of the patients at the time of review was thirty-eight years. There was striking preponderance of males over females (twenty-one males, five females). Operative revision for loss of hip joint movement due to bone proliferation, fibrous ankylosis, bony ankylosis, or faulty relationship, was necessary in nine cases. Four other cases had secondary revisions for stiffness due to sepsis after the first operation. The range of movement and value of the operation is summarised in Table VI.

ARTHROPLASTY FOR TRAUMATIC ARTHRITIS AND MALUM COXAE SENILIS

In contrast with the results of mould arthroplasty in rheumatoid and infective arthritis, and like the results of this operation for complications of femoral neck fractures, the results in traumatic arthritis and malum coxae senilis are most satisfactory. The freedom from pain, excellent range of movement, and stability attained without strain on the back or the opposite hip joint, indicate that arthroplasty may be an ideal line of treatment, provided only that the patient is willing and able to co-operate in after-care. The average age in the cases of traumatic arthritis was forty-one years, and in cases of malum coxae senilis fifty-nine years. In younger patients (with arthritis due to old Legg-Perthes' disease, slipped femoral epiphysis, or fracture-dislocation of the hip joint) where good musculature is more easily redeveloped, it is possible to construct a hip joint closely approximating to the normal

TABLE VII  
TRAUMATIC ARTHRITIS OF HIP  
Follow-up Study of 21 Patients (23 Arthroplasties)  
Range of Movement and Estimation of Value of Operation

Years after operation	Average range of flexion	Condition of hip			
		Satisfactory to patient		Satisfactory to surgeon	
0 - 2	73°	9	2	8	3
2 - 3	115°	2	—	2	—
3 - 4	88°	5	—	4	1
4 - 5	75°	2	—	2	—
Over 5	98°	3	—	2	1

TABLE VIII  
MALUM COXAE SENILIS OF HIP  
Follow-up Study of 15 Patients (16 Arthroplasties)  
Range of Movement and Estimation of Value of Operation

Years after operation	Average range of flexion	Condition of hip			
		Satisfactory to patient		Satisfactory to surgeon	
0 - 2	73°	8	1	8	1
2 - 3	100°	2	—	2	—
3 - 4	80°	2	—	2	—
4 - 5	95°	1	—	1	—
Over 5	100°	2	—	2	—

In older patients, relief from pain, and the ability to lead a relatively normal life with no more than minor inconvenience such as the necessity for using a walking stick in distance walking, are well worth some degree of muscle weakness, limb shortening, and loss of joint movement. Secondary operative revision was necessary for complications due to sepsis after the first operation in one case of traumatic arthritis and one of malum coxae senilis. Secondary revisions were also needed in four cases for hypertrophic bone outgrowths which were interfering with movement (two in each group). In the late follow-up it should be noted that no case showed evidence of aseptic necrosis or bone absorption inside the mould. The range of movement and the value of the operation in both groups of cases are summarised in the Tables VII and VIII.

### CONCLUSIONS

1 In this series of 150 cases of arthritis of the hip joint treated by vitallium mould arthroplasty (182 arthroplasties), 80 per cent of late results are satisfactory to both patient and surgeon.

2 Striking features are the relative painlessness, smooth hip joint movement, progressive improvement in function, and reformation of the joint lines as seen radiographically in the post-operative period.

3 Function after arthroplasty for traumatic and degenerative arthritis approaches the normal hip joint much more closely than in cases of infective and rheumatoid arthritis.

4 There is a complete absence of low back symptoms or postural difficulties, and there is no difficulty in preventing stiffness of the knee joint.

5 Different technical procedures are indicated according to the degree of absorption of the femoral head or neck, and the stability of the mould in the acetabulum.

6 The operative mortality rate in this series was nil, and during the six-year follow-up period only one case died as the result of a complication of the arthroplasty.

7 In addition to meticulous operative technique and the use of special instruments, the importance of careful and prolonged after-treatment must be stressed.

8 It must also be emphasised that secondary operative revisions are often necessary, particularly in cases of infective and rheumatoid arthritis.

### REFERENCE

LAW, W. A. (1947) Results of Treatment of Vitallium Mold Arthroplasty in Complications of Femoral Neck Fractures. *Journal of Bone and Joint Surgery*, 29, 41.

# PLANTAR DIGITAL NEURITIS

## Morton's Metatarsalgia

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*From the Royal National Orthopaedic Hospital*

*Based upon a paper read to the British Orthopaedic Association October 1946*

*"It is high time the profession at large knew that such a distressing and common condition can be so easily and certainly cured"*—The late Sir Harold Stiles

Thomas G Morton (1867) described with remarkable clarity the symptoms of that severe type of metatarsalgia which now bears his name neuralgic pain felt in the sole about

the fourth metatarso-phalangeal joint, radiation of pain to the fourth and sometimes the third toe, onset of pain with walking or standing, and relief of pain by resting with the shoe discarded. There can be little doubt that Morton's syndrome is the same as that which was discussed by Tubby and Sir Robert Jones, and suffered by Sir Harold Stiles.

Until recently the pathology of this condition has remained obscure, largely because surgeons have been loath to explore the cutaneous nerves of the sole for the reason that they feared the possibility of painful scars. In 1940, the late L O Betts of Adelaide reported a series of nineteen patients in each of whom the plantar digital nerve to the cleft between the third and fourth toes had been exposed through a longitudinal incision in the weight-bearing part of the sole. In every case a fibrous swelling of the nerve was found proximal to its point of division and adherent to the transverse metatarsal ligament. In every case resection gave relief from the neuralgic pain. In no case did trouble arise from the scar.

The findings of Betts have given great stimulus to the surgical treatment

of Morton's metatarsalgia. He was too modest to claim originality, but his work appears to have been entirely independent. On a visit to England in 1939 he made extensive inquiries among orthopaedic surgeons, but found none familiar with these gross nerve changes. It is a matter for regret that his untimely death came before the value of his work was appreciated fully.

In this article evidence will be presented which gives general support to the conclusions of Betts, but indicates that the primary lesion is one of local vascular degeneration leading to a wide variety of changes in and around the cutaneous nerve. The observations of Betts, and still more of the author, could not have been made without free access through the sole of the foot.



FIG 1

(Adapted from Spalteholz) To show the relationship of the plantar digital nerves to the flexor brevis digitorum and lumbrical muscles and tendons

## APPLIED ANATOMY

**Cutaneous nerves**—The cutaneous branches of the internal and external plantar nerves appear in the sole of the foot on each side of the flexor brevis digitorum muscle (Fig 1) The digital nerves for the three lateral clefts run an oblique course between that muscle or its tendons, and the plantar fascia, before gaining the spaces between the heads of the metatarsal bones The important 3-4 cleft is generally credited with a dual supply through a main branch from the internal plantar nerve and a small communicating branch from the external plantar nerve *Such a communicating branch is frequently absent* When present, it may equal in size the main branch, with which it fuses just above the transverse metatarsal ligament The nerve, either single or combined, is less than 2 mm in calibre, it is close but not adherent to the ligament In this region it lies in the bottom of a shallow trough, of which the sides are the stout common flexor sheaths and the floor the transverse ligament Superficially the nerve is well protected by the lobulated fat of the sole, interspersed at one level with scattered fibres of plantar fascia Just beyond the ligament the nerve divides to supply the adjacent sides of the third and fourth toes Here it may be exposed with ease through a dorsal incision in the web space The dissected foot shows that *there is no danger of nipping, and no danger of pressure against bone, in any part of the course of the main nerves to the three lateral clefts* We have been able to confirm this fact by taking antero-posterior radio-graphs with fine wires laid alongside the nerves

**Blood supply to the 3-4 cleft**—The third plantar digital artery is the main vessel of the region (Fig 2) It arises from the deep plantar arch, and runs forward between the interossei and the adductor hallucis muscle It rapidly becomes superficial round the distal margin of the transverse head of the latter muscle and appears to emerge from a tunnel in the upper border of the transverse ligament The proximal margin of the tunnel, however, is no more than an oblique slip of fascia from the sheath for the flexors of the third toe The vascular bundle approaches the digital nerve obliquely from the medial side, and runs between nerve and ligament Just beyond the point of division of the nerve it also divides and may be seen to receive the small anterior perforating artery from the dorsum An important variation of this pattern occurs when the origin of the artery is from the neighbouring 2-3 interspace It then has to cross the common flexor sheath for the third toe in order to reach the nerve, during which course it is particularly liable to pressure transmitted through the sole

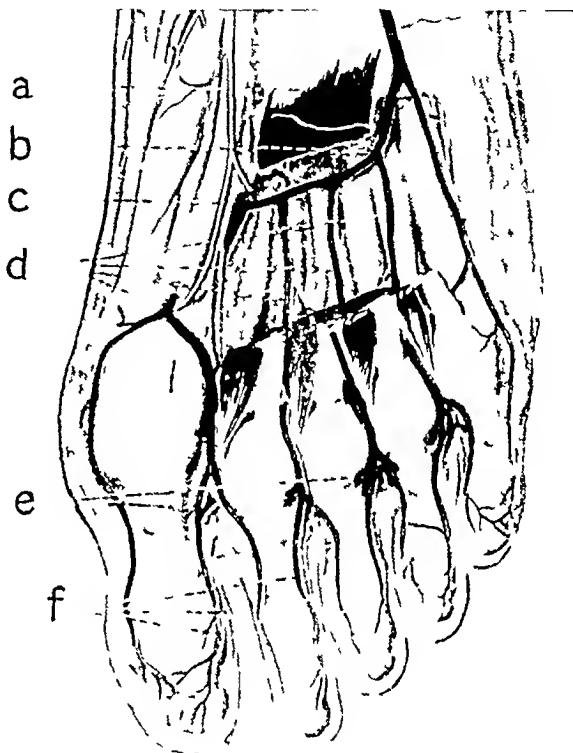


FIG 2

(Adapted from Spalteholz) To show the origin and course of the third plantar digital artery with its relation to the fourth plantar digital nerve (a) adductor obliquus hallucis muscle (b) deep plantar arch (c) perforating branch of dorsalis pedis artery (d) plantar digital arteries (e) anterior perforating arteries (f) collateral digital arteries Adductor transversus hallucis muscle is shown deep to the common flexor tendons and lumbricals

**Other structures**—The fibres of the *lumbrical muscle* to the fourth toe almost reach the transverse ligament, over which the fine tendon runs in intimate contact. The distal margin of the *adductor transversus hallucis muscle* is seen when the digital artery is traced upwards by dividing the oblique slip of fascia mentioned above. The large *inter-metatarso-phalangeal bursa* lies deep to the transverse ligament and seldom contains any free synovial fluid. The *fat*, as elsewhere in the sole, is arranged in well-defined lobules, often sufficiently distinct to feel on palpation like soft tumours. This lobulation is exaggerated when the metatarsal heads are prominent in the sole.

### HISTORICAL REVIEW

Morton (1876) considered that the symptoms arose from compression of branches of the external plantar nerve to the outer side of the fourth toe, between the head of the fifth and the neck of the fourth metatarsal bone. He treated cases successfully by free excision of the fourth metatarso-phalangeal joint.

Writing in 1897 Sir Robert Jones used the term "plantar neuralgia" and described three degrees, the last of which corresponds with Morton's cases. "The third or severe variety comprises those cases where symptoms appear idiopathically or remotely after injury, are persistent in character, do not yield to mechanical measures, and to all effect cripple the patient." Sir Robert advanced the theory of direct pressure on the plantar digital nerves between the sole and the transverse metatarsal ligaments. He suspected organic changes and in a footnote records that Mr Tubby "operated on a case of advanced metatarsalgia and found the nerve swollen and congested." He advocated excision of a metatarsal head, usually the fourth, and advised against nerve resection because of the risk of a painful scar. In 1898, writing with Tubby, he considered that the communicating branch was subject to pressure against the head of the fourth metatarsal bone. There is some confusion as to the final views of Robert Jones because a diagrammatic dissection in "Orthopaedic Surgery" by Jones and Lovett (1929) shows the combined nerve itself running directly under the head of the same bone.

The practice of Tubby (1912) is well remembered by Sir Ernest Rock Carling. "He used to excise the head of the fourth metatarsal through a dorsal incision, and would always look for the plantar digital nerve, though often without success. On the occasions when it was seen the nerve was resected and it often showed more than one small nodule. Large swellings of the size described by Betts were not encountered. Tubby shared Sir Robert's distaste for plantar incisions and to my knowledge did not expose the nerve through the sole."

Over one period, theories of postural strain were popular. For example, D J Morton (1935) regarded the pain as referred from arthritis of the second tarso-metatarsal joint.

Since 1935, the colleagues of the late Sir Harold Stiles have been aware of fibrotic changes in the digital nerve. In a letter to me, written in 1943, Sir Harold described the onset twenty years previously of plantar neuralgia in his own left foot. "The symptoms began with the usual characteristic pain opposite the head of the third metatarsal. Ultimately the pain was so severe that I was obliged sometimes to quit in the middle of a round of golf. The next thing was that severe pain of a typical burning and causalgic nature became localised to a limited area on the adjacent sides of the terminal phalanges of the third and fourth toes." Sir Harold considered that the branch from the internal plantar nerve crossed obliquely under the head of the third metatarsal and was therefore subject to undue pressure. In 1935 he invited Mr Norman Dott to explore the nerves to the 3-4 cleft. Fibrosis of the epineurium of the branch from the internal plantar nerve was found, but the incision was not allowed to encroach on the ball of the foot and no actual enlargement was encountered. Free resection gave complete relief and the short incision in the sole healed soundly.

SH Robert Jones' opinions were widely accepted until Betts published his series of cases in 1940. It is surprising that the gross nerve changes he described had not been discovered many years earlier\*. There is no doubt that some surgeons have encountered painful fibrous nodules on cutaneous nerves of the sole, but without realising that similar changes were to be expected regularly in Morton's metatarsalgia. Others have known of the relief gained by nerve resection without recommending it strongly (Treves *et al*, 1937). In the United States of America, McElvenny (1943), writing four years after Betts' first case, reported a similar series.

Microscopic examination of Betts' specimens showed intense fibrosis with demyelination, but no special comment was made as to the condition of local blood vessels. His conception of the etiology was again a mechanical one. "The fourth nerve is formed by the internal plantar, with a communicating branch from the external plantar, each coming round from opposite sides of the belly of flexor brevis and crossing this obliquely before they unite. When the foot is in action, the flexor brevis contracts, fixing the origin of the nerve, while dorsiflexion of the toes in walking stretches it around the unyielding transverse ligament. The neuritis probably arises in the first place from minor trauma. Once the nerve is swollen from neuritis a vicious circle is set up and the daily irritation is sufficient to keep it up (as in late ulnar neuritis). Pressure from the plantar aspect does not appear to be a factor." A weakness in this argument is the fact, of which Betts was aware, that the communicating branch is often absent. The lesion may also occur in the 2-3 and 4-5 interspaces.

A feature of the earlier literature on Morton's metatarsalgia is the frequency with which the anatomy of the sole is described inaccurately. This has been an important factor in the survival of theories of pressure by bones on the cutaneous nerves.

#### CLINICAL MATERIAL

Patients in this series with pain or disability severe enough to warrant operation numbered twenty-seven. They fall into two separate and differing groups: eleven of a fairly standard pattern seen in 1942-43, and sixteen showing much greater variety seen in 1946-47. The contrasts between the two groups, and the main conclusions drawn from each, may be mentioned briefly before analysing the features of the total number.

**Cases with long history**—The 1942-43 group were seen after a longer duration of symptoms, the shortest times before operation being eight and twelve months, compared with one and two months in the second group. Easily visible changes were found so regularly in the digital nerve to the 3-4 cleft that had a nerve been found of normal calibre this would almost have been regarded as disproving the diagnosis. The enlarged nerves quite overshadowed the digital arteries which were often so degenerate as to be hardly recognisable. However, serial sections of a number of specimens established the degree, extent, and constancy of the vascular degeneration and suggested strongly that changes in the nerve were secondary and ischaemic in character.

**Cases with short history**—The 1946-47 group included four cases explored within two months of the onset of pain. Specimens from these cases have shown that degenerative changes start first in the digital artery and are followed by various degrees of connective tissue proliferation in and round the nerve. Again, there have been more atypical cases with structural abnormalities such as hallux valgus and anterior flat foot.

Of the whole series of twenty-seven cases, twenty-one were women and six men. At the time of operation the two youngest patients were aged twenty-three years, and the two eldest

\* Bickel and Dockerty (1946) point out that Hoadley in 1893 resected a small neurionia on the digital branch of the external plantar nerve to the fourth toe and obtained a prompt and perfect cure.

were aged fifty-three years and fifty-five years. The condition was bilateral in eight cases. The number of feet explored has therefore been thirty-five, of which twenty-one were right and fourteen left. The shortest duration of symptoms was one month. In this case pain was referred to the 2-3 interspace, but the lesion was found in the 3-4 cleft as usual. The longest duration was twenty-six years. This patient remembered vividly that she had been unable to participate in games from the age of eight, because of severe pain in the fourth toe. As a young woman she had repeatedly asked her doctor to amputate the toe. Resection of the nerve at the age of thirty-four gave complete relief. The next earliest age of onset was fourteen years. In no case was there a history of injury or strain at the time of onset more definite than walking on a rough road, or infantry exercises in deep snow.

**Distribution of pain**—Acute pain was almost entirely limited to two contiguous areas, the sole beyond the necks of the third and fourth metatarsal bones, and the entire surface of the corresponding toes (Fig 3).

In twenty-two feet, pain was felt both in the sole and in a toe or toes.

In nine feet, pain was confined to the fourth toe, commonly to the nail-bed and the tip.

In only four feet, was pain confined to the sole.

Not only was pain seldom absent from the toes, but the most acute cases were those in which it was confined to the fourth toe. The word "metatarsalgia," and the term employed by Sir Robert Jones, "plantar neuralgia of third degree," do not indicate the frequency with which the pain is digital.

**Characteristics of the pain**—The pain was typically neuralgic. Most women complained of pain soon after walking on hard surfaces, especially in high-heeled shoes. One could control her pain completely by wearing open sandals, and if it had not been for the rigours of the English winter she would not have sought treatment. Relief was generally obtained by resting with the shoe removed. In severe cases, however, whether early or late, pain sometimes continued through the night with much loss of sleep. A number

of patients had accepted profound alteration in their mode of life in order that the pain might be avoided, several had given up all recreations and took care never to walk more than half a mile at a stretch.

### PHYSICAL EXAMINATION

Most patients had feet of normal form. Recently several have been seen with the combination of hallux valgus and anterior flat foot, but they have insisted that acute pain was an entirely new development, situated *distal* to the old-standing callosities. Apart from a few patients, seen during an acute attack who were suffering exquisite tenderness, physical signs were difficult to elicit. The most constant sign was pain on firm upward and backward pressure in the sole just distal to the third and fourth metatarsophalangeal joints.

**Swelling**—Only one patient had a palpable swelling. This patient, who was shown at the Royal Society of Medicine in 1946, had actual separation of the third and fourth toes.

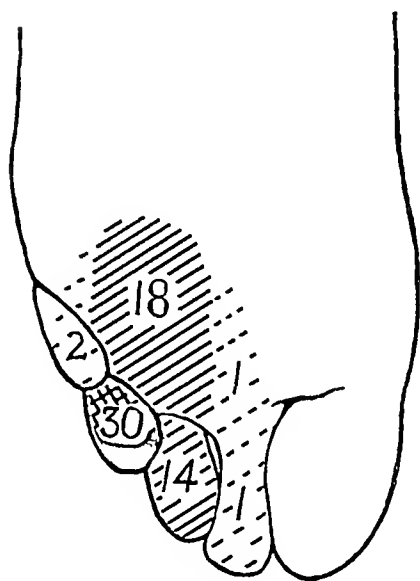


FIG 3

Diagram to show the distribution of pain in thirty-three feet each with a proved lesion in the 3-4 interspace.

(Fig 4) and when standing there was a visible round swelling on the dorsum of each foot. It must of course be recognised that normal lobulation of the fat of the sole may stimulate a small local tumour.

**Anaesthesia**—Diminished sensation to pinprick in the cleft between the third and fourth toes was occasionally found. In a patient who may be accepted as a good witness, this is the most valuable of all signs. Nevertheless, even when there is gross fibrosis of the cutaneous nerve, sensation often appears normal, possibly because there is "take over" from adjacent normal nerves. For the same reason post-operative anaesthesia between the toes rapidly disappears.

**Special radiographic examinations**—X-ray films were taken in most patients, but with the exception of the one case mentioned above they were negative. The blood sedimentation rate was sometimes determined in order to exclude early rheumatoid arthritis. Special examinations such as the quinzarin sweat test (Guttmann 1947) and the tourniquet test for ischaemic pain (Schechter *et al* 1945) have not been used.

#### OPERATIVE TECHNIQUE

Free exposure through a longitudinal plantar incision under general anaesthesia has been the routine (Fig 5). An Esmarch bandage is fixed round the thigh and the patient turned into the prone position with the ankle resting over a sandbag at the end of the table. The third and fourth metatarsophalangeal joints are palpated, and an incision two inches or more in length is made between them, down to the web\*. The incision is deepened, keeping between the common flexor sheaths. When the connective tissue round the nerve is great, it bulges freely into the wound. Usually, however, the nerve has to be sought where it crosses the transverse ligament. (From the practical aspect, if the surgeon is satisfied that the nerve

\* A transverse incision in the tread has some advantages especially when a neighbouring cleft may have to be explored.



FIG 4

X-ray film to show separation of the third and fourth metatarsals and toes (bilateral case). The connective tissue mass round each nerve was roughly spherical and almost an inch in diameter. The soft tissue shadow can be seen in the web space.



FIG 5

Photograph at operation with a blunt hook round the nerve and a dissector beneath the vascular bundle (specimen shown in Fig 6a). An early case with severe pain for two months. There was arterial degeneration but no definite neuroma.



is thickened and adherent to the ligament it is sufficient to resect it in this region without further ado ) The nerve is traced proximally to see how far the changes extend and whether a communicating branch is present. Distally the branches to each toe are defined. The digital artery is found deep to the nerve and traced upwards and medially to determine its source of origin. The whole nerve and vascular bundle are then removed. When there is reason for doing so, one or other of the neighbouring digital nerves may be explored through the same incision. There is no need to tie any vessels. The wound edges are accurately sewn with a blanket stitch. If early ambulation is necessary, a plaster shoe with a generous sponge-rubber heel may be applied over the dressings. When the specimen is to be preserved it should be mounted before fixation in order to avoid distortion.

**After-care**—Neuralgic pain disappears within a few days. The stitches are removed after ten days. If the scar needs protection, dry gauze fixed by elastoplast is used. Full weight-bearing is allowed only after fourteen days. Hot and cold contrast baths, with exercises for the foot and leg, are used at home for a further fortnight in order to control post-operative swelling and stiffness.

**The scar**—Sound scars, free from pain, have been the rule. Slightly tender thickening of either end of the scar may persist for a few months, but the weight-bearing part in the tread seems to "iron out" rapidly. Indeed, if a short plantar incision is to be used, it should be confined to the tread. This experience is in agreement with that of Gaenslen's "split heel" incision for osteomyelitis of the os calcis. A dorsal incision in the web has not been used, mainly because such exposure affords limited access to the nerves and vessels\*.

**Post-operative anaesthesia**—Sensation to pinprick usually returns within a few weeks to adjacent sides of the toes, but a narrow strip of anaesthesia on each side of the scar may persist for several years. Along the margins of the anaesthetic strip hyperaesthesia to light stimuli, such as the putting on of a sock or drying the feet, may also persist. As a matter of interest, Sir Harold Stiles, after submitting to proximal resection of the nerve, complained of hyperaesthesia in the tread distal to his small scar to a degree much greater than any patient in this series. In other words minor post-operative discomfort in the sole has been due more to cutaneous denervation than to the scar itself. Thus, there may be some point in limiting the length of nerve which is resected.

#### FOLLOW-UP REVIEW OF CASES

Of the earlier group of eleven patients, nine have been examined four years after operation. They gained complete relief, although one developed recurrence of pain in the 2-3 cleft a month before re-examination, excision of the corresponding nerve has again given relief (Fig 6c). Of the two patients not re-examined, one, an infantry officer, resumed full training six weeks after operation and remained free from pain until he was killed in action two years later. The other, at that time an able seaman, has written to say that his feet are still painful. In his case the digital arteries were anomalous, they arose from the neighbouring 2-3 clefts, and it may well be that continued symptoms are arising from this cleft.

Of the second group of sixteen patients,\* all have been examined at least three months after operation. Fifteen have complete relief of pain, and only one, a factory cleaner of low mentality, has incomplete relief. One patient, a psychiatrist, had coincident gout which responded to medical treatment. Another, from whom a spherical mass of connective tissue round the nerve almost one inch in diameter was removed from each foot (Fig 4), has recurrence of the swellings and a further exploration may be advisable when permitted by her general condition and the pernicious anaemia from which she also suffers.

\* Baker (1944, 1947) who finds that a dorsal incision is satisfactory maintains that the digital nerve is dorsal to the transverse ligament in 25 per cent of cases. This is incorrect: the nerve is on the plantar aspect of the ligament.

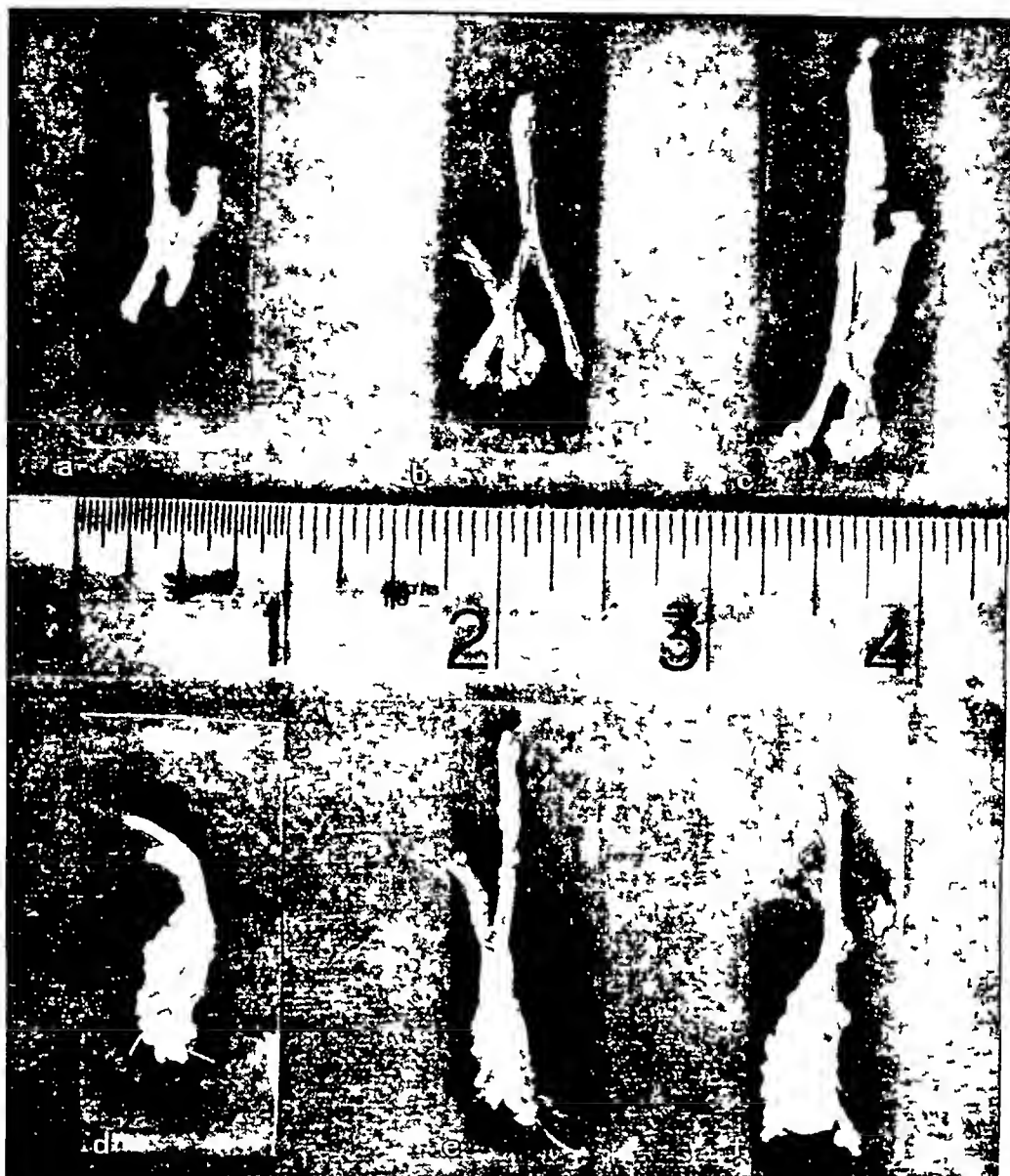


FIG 6

Series of specimens to show the development of visible changes in the artery and nerve  
Except for (d) the specimens are mounted as seen in situ

- (a) Tortuous and slightly thickened artery passing deep to branch of nerve to third toe (*History—pain for two months diffuse, but worst in third toe*)
- (b) Unusually high branching of nerve. Artery running deep to swollen nerve to third toe and then involved in connective tissue (*History—acute pain for one month only extending to second and third toes. Structures in 2-3 cleft found normal*)
- (c) Specimen from 2-3 cleft. Artery surrounded by connective tissue and passing deep to nerve to second toe. Nerve thickened above level of transverse ligament (*History—in 1942 pain fourth right toe for eight months. 3-4 cleft explored and a large capsule found enclosing an asymmetrical lesion affecting fibres to fourth toe. In 1947*
- acute pain in second and third toes of same foot above specimen removed. 1-2 cleft also explored and found normal*)
- (d) Unmounted specimen, side view showing a short degenerated artery with mass of connective tissue deep to fusiform swelling of the nerve (*History—Pain for one year radiating from sole to third and fourth nail-beds*)
- (e) Similar specimen mounted. Small nodules on proximal length of nerve (*History—Pain for six years felt in the sole and fourth toe*)
- (f) Typical asymmetrical lesion with connective tissue surrounding the nerve and branch to fourth toe. The degenerated artery has been cut. The fibrous enlargement of the nerve was much smaller but also asymmetrical (*History—Pain for two years only at tip of fourth toe*)

is thickened and adherent to the ligament it is sufficient to resect it in this region without further ado.) The nerve is traced proximally to see how far the changes extend and whether a communicating branch is present. Distally the branches to each toe are defined. The digital artery is found deep to the nerve and traced upwards and medially to determine its source of origin. The whole nerve and vascular bundle are then removed. When there is reason for doing so, one or other of the neighbouring digital nerves may be explored through the same incision. There is no need to tie any vessels. The wound edges are accurately sewn with a blanket stitch. If early ambulation is necessary, a plaster shoe with a generous sponge-rubber heel may be applied over the dressings. When the specimen is to be preserved it should be mounted before fixation in order to avoid distortion.

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certain late cases of Volkmann's contracture where the nerve lesions are undoubtedly secondary to the ischaemia (Holmes *et al* 1944)

So far no reason has been found why the digital vessels of the 3-4 interspace are particularly subject to degeneration. Anatomically they are related to the transverse ligament



(a)



(b)



(c)

FIG 7

Cross-sections of a typical lesion

- (a) Nerve just above a fusiform swelling showing minor changes ( $\times 25$ )
- (b) Middle of fusiform swelling with marked increase of connective tissue around and between the nerve bundles ( $\times 25$ )
- (c) The vascular bundle with the arterial changes well shown ( $\times 50$ )

more intimately than the digital nerve and occasionally, when derived from the 2-3 interspace, they have first to cross the ridge of the common flexor sheath for the third toe. The most likely factor would seem to be repeated minor trauma to the digital artery from pressure transmitted through the sole.



FIG 3



FIG 4

Case E L female aged 20 years Extra-articular arthrodesis right hip 1935 patient died of pulmonary tuberculosis and tuberculous meningitis five years later Post-mortem specimen shows the solid incorporation and great thickness of the graft (Fig 3) and also intra-articular osseous fusion (Fig 4)



FIG 5



FIG 6

Case A H female aged 8 years Extra-articular arthrodesis 1938 Radiograph before operation (Fig 5) shows extensive tuberculosis of the right hip joint Four years after operation (Fig 6) the graft is solidly incorporated and there is intra-articular osseous fusion

*After-treatment*—The limb is immobilised after operation for a period of from six to nine months. Weight-bearing is usually permitted three months after operation.

TABLE III  
TYPE OF ARTHRODESIS

Type of operation	Number of cases	Per cent
Intra-articular	2	4
Extra-articular	38	76
Combined	10	20
Totals	50	100

Only two intra-articular operations have been performed. One resulted in sound bone ankylosis but the other is still unsound two years after operation. The ten cases of combined arthrodeses were performed early in the series. All resulted in firm bone fusion.

**Complications**—Post-operative complications have been few. In forty-six cases (92 per cent) the wound healed by first intention. Three (6 per cent) developed sinuses which, however, healed before discharge of the patient from hospital. One patient died, the cause of death was toxæmia following complete breakdown of the wound and acute secondary infection. It is probable that the disease was still active at the time of operation. An attempt was made to remove the graft, but firm union appeared to have taken place and this was confirmed at autopsy. No case developed secondary tuberculous foci as a result of the operation, although one died five years later from tuberculous meningitis and pulmonary tuberculosis.

#### END-RESULTS ON DISCHARGE FROM HOSPITAL

The end-results in forty-nine cases, estimated at the time of discharge from hospital, are analysed in Table IV. In thirty-eight (77.5 per cent) there was bony ankylosis, three (6.1 per cent) had sound fibrous ankylosis, eight (16.3 per cent) had unsound fibrous ankylosis, but it is to be noted that in four of these, bone fusion developed subsequently.

TABLE IV  
CONDITION OF THE JOINT ON DISCHARGE

Condition of the joint	Number of cases	Per cent
Wound healed	49	100
Bone ankylosis	38	77.5
Sound fibrous ankylosis	3	6.1
Unsound fibrous ankylosis	8	16.3

The average time elapsing between operation and the development of sound bony ankylosis was 7.8 months. It should be observed that by bony ankylosis is meant solid incorporation of the graft with or without evidence of intra-articular osseous fusion. But even when extra-articular arthrodesis alone is performed, a high percentage of cases develop later evidence of intra-articular bone fusion, due no doubt to the complete immobility which is produced by firm fusion of the extra-articular graft. Of thirty-eight cases in which the operation was strictly extra-articular, twenty-two (57.8 per cent) developed intra-articular bone fusion (Figs 1-6). It has not been possible, however, to determine the length of time which is required for secondary intra-articular fusion to take place.



FIG 7



FIG 8

Case H R female aged 23 years Extra-articular arthrodesis 1945 Radiograph before operation (Fig 7) shows tuberculosis of the right hip Two years after operation (Fig 8) there is solid incorporation of the graft



FIG 9



FIG 10

Case B R male aged 6 years Extra-articular arthrodesis 1939 Radiograph before operation (Fig 9) shows extensive tuberculosis of left hip Two years after operation (Fig 10) the distal half of the graft has undergone absorption there is unsound fibrous ankylosis of the joint but the disease is quiescent

Table V shows the condition of the graft on radiographic examination in forty-seven patients. Firm incorporation occurred in thirty-seven (Figs 3-8), non-union at the trochanteric end was present in eight, but four of these eventually fused. Destruction of the graft occurred in one case. This was in a boy six years of age. Absorption of the distal half of the graft took place through failure of union to the trochanter. The proximal end continued to grow and is seen as a solid buttress of bone, but there is unsound fibrous ankylosis of the joint (Fig 10). One graft fractured near its iliac attachment, and united later, unfortunately there was active disease in the joint which spread to the trochanter and distal part of the graft (Figs 11-13). In no case did sequestration of the graft take place.

TABLE V  
CONDITION OF THE GRAFT ON DISCHARGE  
(As determined by X-ray examination)

Condition of the graft	Number of cases	Per cent
Solid incorporation	37	78.7
Non-union to ilium	0	0
Non-union to trochanter	8	17.2
Fracture of the graft	1	2.1
Destruction of the graft	1	2.1
Sequestration of the graft	0	0
Totals	47	100

Analysis of the condition of the joint and the condition of the graft on discharge according to age groups (Tables VI and VII) shows that the proportion of failures was greatest in the first age group—below ten years. In every case it was at the trochanteric end that fusion failed, and there can be little doubt that failure was due to the high proportion of cartilage to bone in the trochanteric region at this period of life. The most successful results were in the age groups between eleven and thirty years. After the age of thirty, results were again poor.

TABLE VI  
CONDITION OF THE JOINT ON DISCHARGE  
ACCORDING TO AGE GROUPS AT TIME OF OPERATION

Age group (years)	Condition of joint		
	Bone ankylosis	Sound fibrous ankylosis	Unsound fibrous ankylosis
0-10	1 (25%)	0	3 (75%)
11-20	23 (79%)	3 (10.3%)	3 (10.3%)
21-30	12 (100%)	0	0
31-40	2 (50%)	0	2 (50%)

TABLE VII  
CONDITION OF THE GRAFT ON DISCHARGE  
ACCORDING TO AGE GROUPS AT TIME OF OPERATION

Age group (years)	Condition of graft (as determined by X-ray examination)					
	Firm fusion	Non-union to ilium	Non-union to trochanter	Fracture of graft	Destruction of graft	Sequestration of graft
0-10	1 (25%)	0	2 (50%)	0	1 (25%)	0
11-20	23 (79%)	0	6 (20.6%)	0	0	0
21-30	11 (100%)	0	0	0	0	0
31-40	2 (66.6%)	0	0	1 (33.3%)	0	0



## LATE END-RESULTS

Late end-results were considered only after a minimal period of two years from the time of operation. Forty-two patients fulfilled this condition and the group was made up as follows: Untraced 2, Healed disease 38, Active disease 1, Died 1.

The two untraced cases had bone ankylosis of the joint on discharge from hospital and it is probable that they have had no further symptoms. Analysis of the working capacity of the other forty patients is shown in Table VIII.

TABLE VIII  
WORKING CAPACITY

Working capacity	Number of cases	Per cent
Full	35	87.5
Part	1	2.5
Nil	3	7.5
Died	1	2.5
Totals	40	100

The one death occurred in a patient re-admitted to hospital five years after operation with pulmonary tuberculosis; she died from tuberculous meningitis. Post-mortem examination showed that disease in the hip joint was healed, and there was firm bony ankylosis.

**Condition of the joint—**(Table IX) Thirty-five patients (87.5 per cent) have sound bone ankylosis of the hip, two (5 per cent) have sound fibrous ankylosis without symptoms and are in full employment, two (5 per cent) have unsound fibrous ankylosis, and although they are free from symptoms further surgical intervention will probably be necessary.

TABLE IX  
CONDITION OF THE JOINT

Condition of the joint	Number of cases	Per cent
Bone ankylosis	35	87.5
Sound fibrous ankylosis (disease healed)	2	5
Unsound fibrous ankylosis (disease healed)	2	5
Unsound fibrous ankylosis (disease active)	1	2.5
Totals	40	100

One patient only has active disease and is at present under treatment (Figs 11-13). He has developed an abscess in the lateral aspect of the thigh and radiographs show spread of destruction to the trochanter and lower end of the graft. In the earlier stages the graft fractured and it was un-united on discharge from hospital, in spite of active disease the fracture subsequently united. Reviewing this case in the light of his present condition it is reasonable to assume that failure of the extra-articular operation was associated with the large sequestered part of the femoral head, and it would probably have been better to have carried out a combined intra-articular and extra-articular arthrodesis.



FIG 11



FIG 12



FIG 13

Case C A male aged 36 years Extra-articular arthrodesis 1942 Fig 11 shows pre operation film—tuberculosis of the right hip Fig 12 shows the condition on discharge from hospital eleven months after operation there is a fracture of the upper end of the graft Fig 13 shows the condition three years after operation the fracture has united but disease is still active and has spread to the lower end of the graft In view of the sequestration of the femoral head shown in Fig 11 this case might have been treated better by the combined operation (see text)

Working capacity according to the condition of the joint is analysed in Table X. One patient, who has bone ankylosis but whose working capacity is nil, has developed ankylosing spondylitis since discharge from hospital.

TABLE X  
WORKING CAPACITY ACCORDING TO THE CONDITION OF THE JOINT

Condition of the joint	Full	Part	Nil	Died
Bony ankylosis	33	0	1	1
Sound fibrous ankylosis (disease healed)	2	0	0	0
Unsound fibrous ankylosis (disease healed)	0	1	1	0
Unsound fibrous ankylosis (disease active)	0	0	1	0

Recent X-ray examination has been possible in all forty cases reviewed as late end-results, and the condition of the grafts is shown in Table XI. Thirty-five (87.5 per cent) show solid incorporation, in four (10 per cent) there is non-union to the trochanter, one (2.5 per cent) shows some destruction of the graft.

TABLE XI  
CONDITION OF THE GRAFT ON X-RAY

Condition of the graft	Number of cases	Per cent
Solid incorporation	35	87.5
Non-union to ilium	0	0
Non-union to trochanter	4	10
Fracture of the graft	0	0
Destruction of the graft	1	2.5
Sequestration of the graft	0	0
Totals	40	100

Nine of the ten cases discharged from hospital with failed fusion of the graft have been re-examined two or more years from the time of operation. Four now show firm incorporation of the graft and bone ankylosis. Of the other five, two have sound fibrous ankylosis with the disease healed, two have unsound fibrous ankylosis with healed disease, and one shows unsound fibrous ankylosis with active disease. The working capacity of the cases is as follows:

Full	6 (4 bone ankylosis, 2 sound fibrous ankylosis)
Part	1 (Unsound fibrous ankylosis, healed disease)
Nil	2 (1 unsound fibrous ankylosis with healed disease and 1 with active disease)

### SUMMARY

1. Fifty cases of arthrodesis of the hip joint in tuberculous arthritis are analysed, in forty cases the late end-result has been ascertained two or more years after operation.

2. The indications for arthrodesis are discussed. The operation should not be performed when disease is active, it should not be undertaken before the age of twelve to thirteen years, it is not advisable in elderly patients, it may be contra-indicated when there are multiple foci of infection. Subject to these limitations every patient with unsound ankylosis after adequate conservative treatment should be treated by arthrodesis, painful fibrous ankylosis and late onset of deformity are definite indications.

3 Three types of operation have been used intra-articular arthrodesis, extra-articular ilio-femoral arthrodesis, combined intra- and extra-articular arthrodesis. Extra-articular ilio-femoral arthrodesis is preferred, deformity being first corrected by traction or osteotomy.

4 Post-operation complications were few, the mortality rate was low (2 per cent.)

5 There was bone ankylosis with solid incorporation of the graft in 87.5 per cent., failure of union of the graft (to the trochanter) in 10 per cent., and destruction of the graft in 2.5 per cent.

6 Late end-results show full working capacity in 87.5 per cent. of patients, part working capacity in 2.5 per cent. and inability to work in 7.5 per cent.

The writer wishes to express his thanks to Professor Harry Platt and Professor T. P. McMurray for criticism and advice in the preparation of this paper, and to Dr F. C. S. Bradbury, Central Consultant Tuberculosis Officer of the Lancashire County Council, for permission to publish these cases.

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# THE BEHAVIOUR OF PENICILLIN IN SYNOVIAL CAVITIES

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*Read at the Spring Meeting of the British Orthopaedic Association, April 1947*

In the treatment of joint infections with penicillin it must be possible to rely upon adequate concentration of the drug within the joint. Rammelkamp and Keefer (1943) suggested that synovial membrane was a barrier to the passage of penicillin from the blood stream. Accordingly the writer investigated the use of local injection into the joint. If penicillin does not get into a joint easily, it should not get out easily, and this proved to be the case in this series.

Table I is a record of twenty-five knee joints in which thirty-two estimations of penicillin concentration were made forty-eight hours after the injection of a single dose of 100,000 units into the joint. Where two values are given, the second was after a further injection at a later date when no penicillin remained in the joint from the first injection. All these joints had open war wounds. At the original operation the synovial membrane alone was closed by interrupted suture, the wound itself and secondary incisions were left open. The operation was completed by the injection of 100,000 units of penicillin into the joint cavity in 5-10 c.c. fluid. The limbs were then immobilised in Thomas knee splints, with light traction, and plaster of Paris of a modified "Tobruk" type, leaving the knee joint exposed.

Penicillin estimations were made by the crude cup method against the standard Oxford H strain of staphylococcus aureus, using a single drop of synovial fluid in one cup, and a similar drop of calcium-penicillin solution 100 units per c.c. in another cup as control. The figures given in the second and third columns refer to the radius, in millimetres, of the zone of inhibition of growth of organisms round the cups after incubation. This method should be quite accurate for our purpose which is to recognise only a bacteriostatic concentration in the fluid. Any value above 0 is therefore satisfactory. No penicillin was given by other routes in any of these cases.

Penicillin is still present in adequate concentration in twenty-four of the thirty-two estimations. Table II shows that, sometimes at least, it can be found as long as eighty-four hours after injection (Case 16). What are the factors which govern the length of time penicillin persists? First one would think that in joints with marked bone damage the drug would leak into surrounding tissues, or be absorbed rapidly from raw bone surfaces. I have indicated in the chart the severity of bone damage from 0 to + + +, 0 indicating only slight cartilage injury and + + + extensive shattering with fractures extending into the bone shaft. It will be seen readily that there is no relationship between the extent of damage and the persistence of penicillin (note especially Case 19 in Table II with most severe damage and yet effective penicillin concentration after seventy-two hours, and Cases 29A and 31A with no bone injury and yet with negative values at forty-eight hours). It is to be presumed that the sealing off by clot and haematoma effectively prevents absorption. This observation may also be true in wounds of soft tissues.

An observation which I think is of some importance is the variation of penicillin concentration according to the "tidal" behaviour of the joint. When the tide is coming into the joint in the form of increasing effusion, penicillin always persists for over forty-eight hours, and has been recorded up to eighty-four hours in adequate concentration (Case 16, Table II). When the tide is going out, and the joint is actively absorbing effusion, we find that the penicillin goes with it and does not last even for forty-eight hours. This tide is indicated in the chart by 0 when it is coming in or stationary,  $\pm$  when it is beginning to turn, and + when it is going out and the joint is actively absorbing effusion. In every case in which no effective penicillin was found after forty-eight hours, the joint was always absorbing effusion actively. This observation is particularly notable in Cases 25, 30, 31, and 34, where two estimations were made at different stages.

TABLE I  
ESTIMATIONS OF PENICILLIN CONCENTRATIONS IN 25 KNEE JOINTS  
48 hours after intra-articular injection of 100 000 units

Case number	<sup>1</sup> Assay of synovial fluid	<sup>1</sup> Control	<sup>2</sup> Degree of bone injury	<sup>3</sup> Clinical absorption phase of joint
7	10	14	0	0
8	20	20	+	0
16	3	13	0	0
19	3 5	12	+++	0
20	2 (60 hrs )	14	++	0
23	2 5	13	++	0
24	1	11	0	±
25	4 0	13 14	+	0 +
27	0	13	0	+
28	5	14	+	0
29	6	14	+	0
29A	0	14	0	+
29B	8	14	+	±
30	8 0	14 14	++	0 +
30A	4	13	0	0
30B	2 5	13	0	0
31	5 3	13 13	+++	0 ±
31A	0	13	0	+
32	0 0	14 14	++	± +
32A	6	14	0	0
33	4 5 5	13 13	+	0 0
34	5 0	12 12	++	0 +
35	5 3	13 13	0	0 0
37	7	14	+++	0
38	2	14	0	±

<sup>1</sup> Assay of synovial fluid and Control—Figures indicate radius in millimetres of zone of inhibition of growth of micro organisms after incubation

<sup>2</sup> Severity of bone injury—Indicated in degrees from 0 (slight injury to articular cartilage) to +++ (extensive shattering of bone)

<sup>3</sup> Clinical absorption phase—No absorption (effusion increasing) 0 Beginning absorption of effusion ± Active absorption of effusion +

# HAEMATOGENOUS OSTEITIS IN CHILDREN

## Preliminary Report on Treatment with Penicillin

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During the first eighteen months in which penicillin was available in the Glasgow Royal Hospital for Sick Children, fifty-six cases of osteitis were treated in one surgical unit. Of these, thirty cases were acute with marked toxæmia, in nine cases the bone lesion was the outstanding feature and toxæmia was slight, the remaining seventeen cases were admitted for the treatment of chronic pyogenic bone infection. The term osteitis is used throughout this paper as meaning acute or chronic infection of bone tissue, it includes the conditions known as osteomyelitis and periostitis.

### ACUTE OSTEITIS

The clinical features of osteitis as seen in this hospital before the introduction of penicillin have been described by White (1937). There has been little change in the incidence of the disease in Glasgow since the beginning of the century, and before the introduction of chemotherapy there was little tendency for the mortality to diminish. Most cases were admitted with toxæmia, and death often occurred from overwhelming blood infection. Treatment of the local bone focus had little, if any, effect in arresting progress of the disease. Surgical treatment included immobilisation, incision of soft tissue abscesses, drilling and guttering, diaphysectomy, and even amputation. Necropsy in fatal cases confirmed such lesions as empyema, lung abscess, purulent pericarditis, and widespread pyæmic abscesses. Of 250 cases of osteitis admitted to one unit during a period of ten years before the introduction of penicillin, 139 were of this septicaemic type. There were thirty deaths—a mortality of 21 per cent. Most cases treated during the second half of the period received sulphathiazole, Table I shows the resulting fall in mortality which was considerable.

TABLE I  
MORTALITY IN THE SEPTICAEMIC TYPE OF OSTEITIS BEFORE  
THE INTRODUCTION OF PENICILLIN

Years	Number of cases	Deaths	Mortality
1936-40	69	23	33.3 per cent
1941-45	70	7	10 per cent

**Present series**—Of the cases treated with penicillin, thirty were of the septicaemic type. The average age was six years and the proportion of boys to girls was three to two. The site of lesions is given in Table II.

**Investigation of cases**—Blood was taken for culture as soon as possible after admission of the patient, and this was repeated on the second, third, fifth, seventh, and tenth days. Marrow culture was not carried out routinely, but in suitable cases it was performed in the theatre and repeated on the seventh, fourteenth, and twenty-first days. The organism obtained from blood culture, marrow puncture, or by aspiration of abscesses, was typed and

its sensitivity to penicillin assessed. White blood cells were counted and erythrocyte sedimentation rates measured. Penicillin blood levels were assessed after intramuscular drip administration and after injections at three, four, five, and six-hourly intervals. Assays were also made after single injections of an oil-wax suspension of penicillin. Blood levels were estimated by the slide-cell method (Bigger *et al* 1944). Radiographic examinations were performed on the tenth, fourteenth, twenty-first, and twenty-eighth days and at two, three, four, and six months.

**Results of investigation**—A coagulase-positive staphylococcus aureus was grown from the blood in 56 per cent of cases, no positive culture was found after the seventh day of treatment. The causative organism obtained from soft tissue abscess or marrow cavity was a staphylococcus aureus, sensitive to penicillin in approximately the same degree as the standard Oxford staphylococcus. No resistant strains were found. No organisms were grown from the marrow after the fourteenth day of treatment in any case in Table II. Penicillin was continued for a further seven days after marrow cultures had been reported sterile. White blood counts and erythrocyte sedimentation rates were found to be of little value in assessing either the degree or the duration of infection.

Using the method of continuous intramuscular administration, with a daily dose of 100,000 units of penicillin in 100 c.c. of sterile saline, adequate penicillin blood levels were found on all occasions. When using intermittent intramuscular injections we failed to confirm the therapeutic levels maintained by Buchanan (1946) with six-hourly injections. Irrespective of age and body weight, it was the exception to obtain complete inhibition of the standard staphylococcus beyond four hours. If the individual dose was less than 30,000 units, injections were given at three-hourly intervals, doses of 30,000 units and over were given at four-hourly intervals. Therapeutic blood levels were thus maintained constantly. With wax and oil suspensions of penicillin we were unable to maintain therapeutic blood levels for the periods suggested by other workers (Hughes 1946). Although a single injection of 125,000 units may give an adequate level for more than twelve hours, no inhibition of the standard staphylococcus in undiluted serum was found after seven hours in several young children who were given this dose. However, a more recent preparation of 300,000 units per c.c. (Glaxo) always gave a therapeutic level for at least twelve hours after a single injection.

**Treatment**—The aim of treatment is to control septicaemia and reduce tension in the local bone focus. The relief of tension serves the threefold purpose of easing pain, lessening absorption, and preserving blood supply of the bone. If the infecting organism is penicillin-sensitive, and penicillin therapy is instituted early, these objects should be achieved without surgical intervention (Florey and Florey 1943). Unfortunately, however, the type of case under consideration was seldom admitted to hospital until tension in the bone had caused irreversible bone change. Treatment is considered under three headings: immobilisation, penicillin administration, and operative procedure.

**Immobilisation**—After complete local and general examination of the patient, the affected part was immobilised. The limb must however be available for inspection and it should not be enclosed in plaster during the first fourteen days of treatment. In two early cases an unsuspected soft tissue abscess formed under a plaster cast, and evacuation of pus was unduly delayed (Cases 5 and 14). A fibre abduction splint was used for osteitis of the humerus, skin traction for pelvic and upper femoral lesions, and a posterior plaster-of-Paris gutter, or padded Cramer wire splint, for all other lesions of the lower limb. Immobilisation was continued in order to avoid pathological fracture as the bone became progressively decalcified. During this period a sling was used for the upper limb, a walking caliper in upper femoral lesions, and a walking plaster for lesions below the level of the middle third of the femur. Immobilisation was continued until radiographic examination showed sound consolidation—that is to say for periods of from two to eight months.



TABLE II  
ANALYSIS OF THIRTY CASES OF SEPTICÆMIA DUE TO OSTIUM ILLICITUM BY PENICILLIN

Case No.	Age	Site	Days ill	Blood culture	Pus	Complications	Surgical treatment	Penicillin			Days in hospital	Radiographic appearances	Result
								Route	Total dose (units)	Duration (days)			
1	7½ years	Humerus	7	Sterile	Staph. Aureus	—	Incision of abscess	I M drip	1 200 000	12	36	1 week osteitis humeri with intra and extra pelvic abscesses 3 weeks gross decalcification still well 5 months no evidence of osteitis	Cure at 6 months
2	6½ years	Femur (lower)	3	Staph. Aureus	—	—	Immobilisation	I M drip	1 200 000	12	21	2 weeks raised periosteum 3 weeks decalcification metaphysis 3 months healed osteitis	Cure at 3 months
3	6 years	Femur (upper)	4	Staph. Aureus	—	—	Skin traction	I M drip	1 000 000	10	21	2 weeks raised periosteum 3 weeks decalcification neck of femur 16 weeks healed osteitis	Cure at 4 months
4	3 years	Femur (lower)	1	Staph. Aureus	Staph. Aureus	*Scarlet fever 24th day metastases to tibia and fibula	(1) Immobilisation (2) Multiple sequestrectomies	I M drip	1 400 000	14	24*	3 months cavities femur and tibia, sequestra in fibula 17 months healed osteitis	Apparent cure lump due to 11" lengthening of affected limb
5	9 years	Calcaneus	2	Sterile	Staph. Aureus	—	Incision of abscess, 8th day	I M drip	1 100 000	11	35	1 week decalcification 20 weeks decalcification and cavities 8 months healed osteitis	Slight limitation of ankle movements at 8 months
6	10 years	Femur metatarsal	7	Sterile	Staph. Aureus	Arthritis knee	Aspiration of knee incision foot and thigh sequestrectomy at 14 months	I M drip	900 000	9	22	1 week decalcification femur and metatarsal 12 weeks cavity with sequestrum femur 18 months consolidation complete	Cure at 18 months

8	F	3 years	Tibia (upper)	4	Sterile	—	Immobilisation	I M drip	1 100 000	11	14	1 week raised periosteum 3 weeks patchy decalcification 12 weeks healed osteitis	Cure at 3 months
9	F	3 weeks	Femur (bipolar)	4	Staph Aureus	Staph Aureus	Arthritis hip and knee	Aspiration hip and knee incision of abscess	1 100 000	11	32	2 weeks effusion hip and knee periostitis femur destruction lower epiphysis of femur 6 and 12 months gross deformity lower end of femur	Walks with limp at 14 months movement knee full and painless
10	F	2 months	Third lumbar vertebra	12	—	Staph Aureus	Flaccid paralysis both legs on admission	Incision of abscess and resection primary suture	264 000	11	25	2 weeks osteitis 8 weeks no evidence of osteitis	Slight drop foot (R) at 7 months
11	F	7 1/2 years	Femur metatarsal	2	Sterile	—	—	P O P case—sequestrectomy femur at 13 months	1 100 000	11	55	3 weeks decalcification ++ new subperiosteal bone 8 weeks decalcification ++ involucrum formation 6 months cavity with sequestrum 16 months healed osteitis	Cure at 16 months 1 lengthening
12	M	6 years	Tibia (bipolar)	5	Sterile	Staph Aureus	—	Incision and bone drilling sequestrectomy at 6 months	1 100 000	11	14	3 weeks raised periosteum decalcification entire shaft 2 months large sequestrum 13 months healed osteitis	Cure at 13 months 1 1/2 lengthening
13	M	5 years	Tibia (bipolar)	2	Staph Aureus	Sterile after 3 days penicillin	Acute suppurative otitis media convulsions pneumonia	Incision bone drilling and suture 3rd day	1 000 000	10	82	3 weeks decalcification 8 weeks new subperiosteal bone decalcification 9 months healed osteitis	Cure at 9 months
14	M	6 1/2 years	Femur (lower)	5	Sterile	Staph Aureus	—	P O P Case—aspiration of abscess after 7 weeks sequestrectomy 9 months	2 300 000	21	69	2 weeks raised periosteum patchy decalcification 5 months large sequestrum 12 months healed osteitis	Cure at 12 months

TABLE 11—continued  
ANALYSIS OF THIRTY CASES OF SEPTICÆMIA RELATED BY PENICILLIN

Case No.	Sex	Age	Site	Days ill	Blood culture	Pus	Complications	Surgical treatment	Penicillin	Days in hospital	Radiographic appearances	Result
15	M	4½ years	Femur	7	Staph. Aureus	—	—	Immobilisation	I M drip Total dose (units) 900 000	38	3 weeks decalcification entire shaft 8 weeks decalcification ++ 7 months healed osteitis	Cure at 5 months
16	M	4½ years	Ischium	7	Staph. Aureus	Staph. Aureus	Large extra- and intra-pelvic abscess	Aspiration and local instillation of penicillin × 2	I M drip Total dose (units) 1 200 000	85	1 week effusion right hip 3 weeks decalcification right ischium 4 weeks osteitis ischium—abscess 12 weeks healing lesion 4 months healed osteitis	Limp at 4 months Cure at 6 months
17	F	9 years	Femur (lower)	9	Staph. Aureus	Staph. Aureus	Arthritis knee	Aspiration knee incision abscess 6 months—sequestrectomy	I M drip Total dose (units) 1 000 000	25	10 days raised periosteum decalcification 8 weeks decalcification ++ new subperiosteal bone 12 weeks cavity with sequestrum 10 months bone consolidated	Roller-skating in full length P O P at 8 weeks Cure at 10 months
18	F	10 years	Femur (lower)	5	Sterile	—	Synovitis knee	Aspiration knee	I M drip Total dose (units) 1 400 000	28	2 weeks decalcification lower metaphysis 4 weeks increased decalcification 7 months healed osteitis	Cure at 7 months
19	F	7½ years	Femur (upper)	2	Staph. Aureus	Staph. Aureus	—	Incision and bone drilling sequestrectomy at 6 months	I M drip and injection Total dose (units) 2 200 000	18	2 weeks raised periosteum and patchy decalcification 4 weeks sequestrum new bone ++ 9 months bone consolidated	Cure at 9 months
20	M	5 years	Femur (lower)	4	Sterile	—	—	Immobilisation	I M drip Total dose (units) 1 100 000	20	2 weeks raised periosteum and patchy decalcification 4 months healed osteitis	Cure at 4 months

No.	Sex	Age	Site	Organism	Operation	Drugs	Amount	Time	Remarks
22	M	8 years	Femur (lower)	Staph. Aureus	Incision and drilling suture	—	1 700 000	9	12 weeks sequestrum smaller 6 months healed lesion
23	F	8 years	Humerus (bioplar)	—	Abduction splint	—	1 600 000	8	2 weeks raised periosteum 4 weeks decalcification 4 months healed osteitis
24	M	1½ years	Femur (lower)	Staph. Aureus	Immobilisation	—	1 100 000	21	10 days decalcification 3 weeks raised periosteum 6 months healed osteitis
25	M	2½ years	Tibia (lower)	Sterile	Incision and suture	—	2 300 000	21	2 weeks raised periosteum 3 weeks patchy decalcification 3 months healed osteitis
26	F	7 years	Tibia (lower)	Staph. Aureus	Incision	—	2 100 000	21	2 weeks raised periosteum 4 weeks increased decalcification 5 months healed lesion
27	M	7 years	Femur (lower)	Sterile	Incision and suture	—	7 800 000	23	2 weeks raised periosteum 4 weeks increased decalcification 4 months small cavity lower tibia
28	M	11½ years	First metatarsal	Staph. Aureus	Incision and suture	—	8 400 000	21	3 weeks new subperiosteal bone 7 weeks gross decalcification 4 months small cavity femur
29	M	5 years	Femur (upper)	Sterile	Incision and suture	—	3 900 000	20	3 weeks early decalcification 4 weeks increased decalcification 4 months healed osteitis
30	M	2½ years	Humerus (upper)	Staph. Aureus	Incision and suture	—	6 300 000	21	2 weeks raised periosteum 4 weeks decalcification shafts 3 months recalcification 4 months healed osteitis

*Penicillin administration*—Penicillin administration was started as soon as blood was withdrawn for culture. During the first twelve months of the period under review, penicillin was given by continuous intramuscular drip, 100,000 units in 100 c c of sterile saline each twenty-four hours, using the Eudrip No. 3 apparatus (McAdam *et al* 1944). Administration was continued for ten to fourteen days. A therapeutic blood level was found in each specimen of blood assayed (Buchanan 1946). Subsequently, owing to difficulties with drip infusions, we reverted to intermittent intramuscular injection. After the work of Buchanan (1946) we used a dose of 5000 units per lb. body weight each twenty-four hours. A scheme of dosage, shown in Table III, was drawn up for convenience in dispensing and to serve as a guide to the resident medical and nursing staffs.

TABLE III

SCHEME OF PENICILLIN DOSAGE USED AS GUIDE TO RESIDENT MEDICAL STAFF

Age group	Dose each 24 hours	Frequency and Route
Birth - 3 months	80 000 units	Three-hourly by mouth
3 months - 6 months	80 000 units	Three-hourly by intramuscular injection
6 months - 12 months	120 000 units	Three-hourly by intramuscular injection
1 year - 5 years	200 000 units	Three-hourly by intramuscular injection
5 years - 10 years	300 000 units	Four-hourly by intramuscular injection
10 years - 12 years	450 000 units	Four-hourly by intramuscular injection

Penicillin is maintained in the ward refrigerators in strengths of 5000  
10 000 and 15 000 units per c cm. and of 25 000 and 50,000 units per  
2 c cm. in pyrogen-free sterile saline

Administration of penicillin in the dosage shown was continued for twenty-one days, or until the marrow culture was reported sterile (whichever was the longer), and the total dose varied from 11 to 84 mega units according to age. When intermittent injections appeared to disturb a child during the night, penicillin in a dose of 300,000 units in 1 c c of wax-oil suspension was given at six p.m. At six a.m. the intermittent injections were recommenced.

*Surgical procedure*—If pus was obviously present in soft tissues when the patient was admitted, general penicillin administration was started in the dosage shown in Table III and the limb was immobilised. Pus was evacuated within twelve hours by aspiration or incision, such procedures being undertaken not more than one hour after an injection of penicillin so that a high level was present during the operation. After aspiration of pus, 50,000 to 100,000 units of penicillin were injected into the abscess cavity. In the first ten cases which were incised, the wounds were lightly packed with vaseline gauze. The soft tissues were "frosted" with penicillin-sulphathiazole powder. If the bone was drilled, penicillin was instilled into the marrow cavity. Subsequently, however, all wounds were sutured with silkworm gut in order to restore continuity of periosteum, to avoid secondary infection with penicillin-insensitive organisms, and to prevent the formation of penicillinase. Suturing was sometimes complete, or an indwelling rubber tube was inserted with terminal perforations through which 100,000 units of penicillin were slowly instilled, the tube then being occluded by spigot or linen thread and carefully wrapped in sterile gauze. Each morning aspiration through the indwelling tube was attempted and the fluid was sent for culture and penicillin assay, 100,000 units were again instilled, careful aseptic technique being observed. The tube was usually removed on the fourth day, sequestrum formation did not occur in any of the sutured cases, and all wounds healed by first intention.



FIG 1

Case 11 Female child aged seven years acute osteitis lower shaft of femur with cavitation and sequestration which healed within sixteen months but with one inch of true lengthening of the diseased bone

If, on admission, there was no evidence of pus formation in the soft tissues the limb was immobilised and general penicillin therapy instituted. Until laboratory data were available it was presumed that the infecting organism was penicillin-sensitive. If, however, pain, tenderness, and signs of toxæmia were not relieved within forty-eight hours, operative treatment was undertaken in order to reduce the tension of pus under the periosteum. Increasing swelling, tenderness, or erythema were obvious indications for surgical intervention. Bone drilling was performed in six cases—always with dramatic relief from pain. It is now

considered that such interference should seldom be necessary and for the past eight months no bone drilling has been carried out. Three cases with staphylococcal arthritis of the knee joint were treated by aspiration with one local injection of penicillin. The results of the different methods of treatment are summarised in Table IV.

TABLE IV  
ANALYSIS OF SURGICAL PROCEDURES IN THIRTY CASES OF  
ACUTE OSTEITIS OF SEPTICAEMIC TYPE

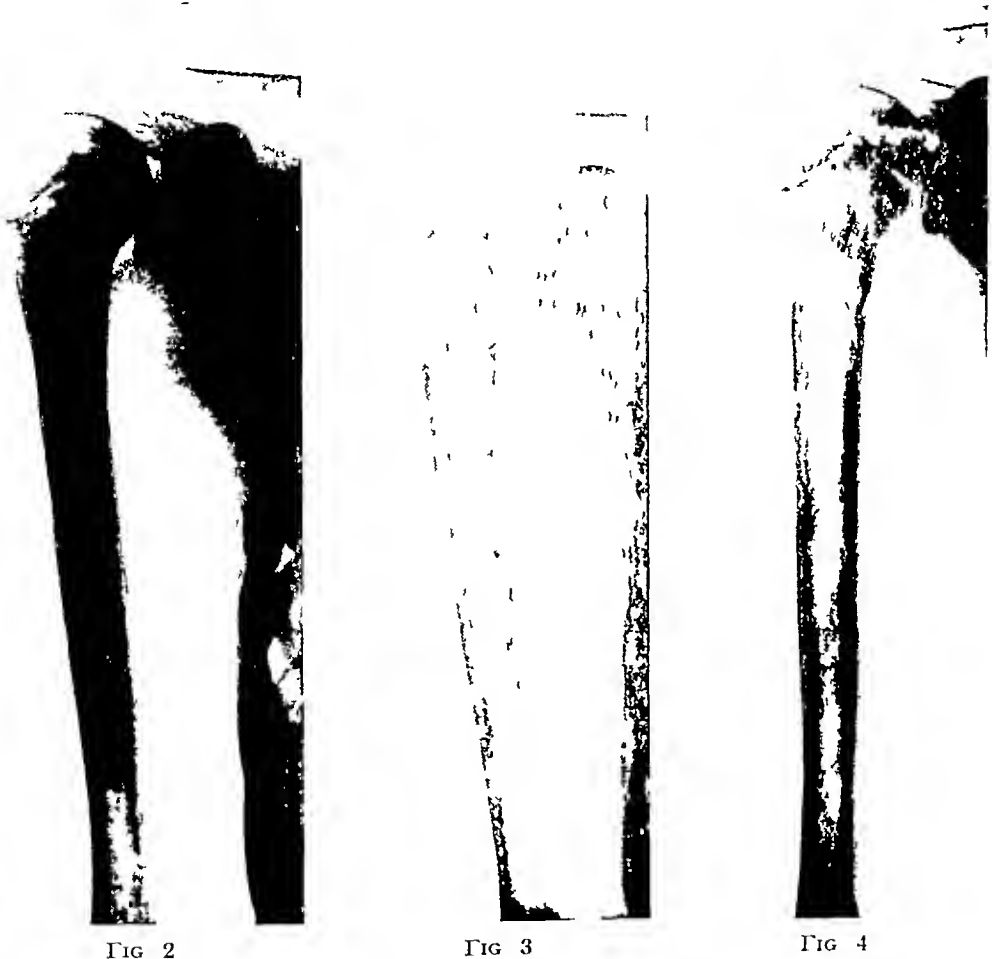
Treatment	Number of cases	Healed	Consolidation not yet complete	Sequestrum formation
Immobilisation alone	9	8†	—	1*
Aspiration	3	2	—	1*
Simple incision	12	8	2	2*
Incision and bone drilling	6	4	—	2*
* Sequestrectomy performed with primary suture and healing per primam, all bones now soundly consolidated				
† One case developed scarlet fever twenty-fourth day (Case 4) Now healed				

**Results**—In this series there have been no deaths, no pathological fractures and no ankylosed joints. The average duration of stay in hospital was thirty-two days. Adherent scars developed in two cases only. No case showed sinus formation. Recovery from septicæmia, although not immediate, was dramatic, and seldom was a patient gravely ill after the fourth day (Cases 13 and 16). Low grade pyrexia sometimes continued for a further seven days, but the general condition caused no anxiety. In seven patients who required no operation, severe pain was relieved within forty-eight hours of instituting treatment. Of the thirty patients, twenty-eight are well, and radiographs show no evidence of bone disease. Complete consolidation of bone required periods varying from three to fourteen months, the average being five months. Case 11 shows one inch increase in the length of the affected limbs (Fig 1), and Cases 12 and 26 have genu valgum with half an inch increase in length of the affected tibia. Case 13 was admitted with convulsions and acute suppurative otitis media which required myringotomy. He developed staphylococcal pneumonia and remained in hospital for twelve weeks. Case 4 developed scarlet fever on the twenty-fourth day. On return from a fever hospital twelve weeks later, metastases were present in two other bones. After multiple sequestrectomies, cure appears to be complete, seventeen months after onset. Case 11 had flaccid paralysis of both legs on admission. Apart from weakness in dorsiflexion of the right foot, recovery was complete when the child moved to the South of England after seven months. Cases 6, 9, and 17 were admitted with arthritis of the knee joint. Movements are full and painless in all cases, but radiographs in Case 9, when twelve months old, show gross deformity of the lower femoral epiphysis.

Sequestrum formation requiring surgical interference occurred in six cases (6, 11, 12, 14, 17, and 19). These sequestra have been removed, and after primary suture all wounds remained healed. The two remaining cases are free from pain, they are no longer immobilised, but recalcification is not yet complete four to five months from onset. The results are detailed in Table II. They are comparable with those of McAdam (1945) and Trueta (1946).

**Radiographic appearances**—There was a striking absence of dense involucrum formation so that radiographic changes were more readily seen than in days before the introduction of penicillin. During the first few days soft tissue oedema may be seen deep to

the muscle planes. Between the tenth and fourteenth days there was evidence of raising of the periosteum, of a translucent area of decalcification in the metaphysis, or of both these changes simultaneously. After twenty-one days new subperiosteal bone was visible and further patchy areas of decalcification appeared. Decalcification was progressive over a period of two to four months, it was often exaggerated by generalised decalcification of the immobilised limb. Since the decalcified shaft was no longer supported by a dense involucrum, the risk of pathological fracture made it advisable to prolong the period of protective immobilisation. Loss of blood supply and sequestration of bone was usually evident after four



Figs 2-4 Case 23 Acute osteitis of the humerus. On admission there was no radiographic evidence of a bone lesion except that the films showed soft tissue swelling. By the tenth day (Fig 2) there was a translucent area in the upper metaphysis. At the third week there was patchy decalcification of the shaft and early subperiosteal bone formation. By the fifth week (Fig 3) there was clear evidence of subperiosteal bone formation and of small cavities in the shaft and metaphysis containing sequestra. During the third month the bone recalcified, sequestra underwent absorption and the cavities disappeared. Within six months (Fig 4) healing was almost complete.

weeks by the appearance of areas of increased density. Small sequestra, and when there was no secondary infection large sequestra, were often absorbed. New subperiosteal bone was laid down in onion layers and recalcification of the shaft took place (Figs 2-4). Measurable increase in length of the affected bone appeared only in three cases (Fig 1).



SUBACUTE OSTEITIS (Williams *et al* 1932)

In nine cases of osteitis, toxæmia was not severe and the life of the patient was never in danger. In seven cases the infecting organism was a staphylococcus aureus and in two cases a penicillin-sensitive streptococcus.

*Benign character of streptococcal osteitis in children*—In infancy, osteitis is frequently due to a streptococcus and the disease differs from staphylococcal infection in several respects. Severe toxæmia is unusual and abscess formation and joint infection are common—probably due to the thin and porous infantile cortex and delicate epiphyseal cartilage. Sequestration is rare and sequestra are usually absorbed spontaneously. Bone deformities are quickly rectified by growth and full joint function is restored early. Even before the introduction of antibiotics these cases responded well to minor surgical intervention and in only two cases in the past eighteen months was penicillin administration considered necessary.

**Treatment of subacute osteitis**—Penicillin was given in the dosage shown in Table III. A patient with extensive osteitis of the parietal bone and a discharging sinus was treated with local and parenteral penicillin for seven days. The sinus was then excised, the necrotic outer table curetted and the wound sutured after "frosting" with penicillin-sulphathiazole powder. Healing was uneventful, penicillin was discontinued on the eighth day after removal of the stitches. Within one month there was no clinical evidence of a bone defect and radiographic examination showed a healed lesion. Of two cases of osteitis of a rib with large soft tissue abscesses, one resolved rapidly after aspiration of pus and injection of penicillin, in the other, the abscess was incised and healed after primary suture. In each case, parenteral penicillin was continued for twenty-one days. Three cases (streptococcal infection of the humerus, and staphylococcal infections of the tibia and fibula) treated by penicillin for twenty-one days, healed without surgical intervention. One case of streptococcal osteitis of the ilium required open drainage of a large retro-peritoneal abscess, penicillin was instilled through an indwelling tube for four days and given parenterally for three weeks, healing was complete in ten weeks. One case of osteitis of the lesser trochanter was given intramuscular injections of penicillin for twenty-one days and recalcified satisfactorily after ten weeks.

## CHRONIC OSTEITIS

The indications for surgical treatment were pain in the bone, pain or swelling in an associated joint, and sinus or abscess formation. The presence of a cavity or sequestrum is not necessarily an indication for surgical treatment. When there was cavitation or sequestrum formation after treatment of acute osteitis, the patient was given penicillin in the dosage given in Table III for five days, the cavity then laid open, the sinus excised, granulations and sequestra removed and the cavity saucerised. Bone chips from surrounding healthy cortex were sometimes inserted. The tissues were "frosted" with penicillin-sulphathiazole powder, a fine-bore rubber tube inserted into the depths, and the wound closed with silk-worm gut. After instilling 100,000 units of penicillin, the limb was immobilised in plaster of Paris. After daily injection of 100,000 units, and also parenteral administration of penicillin, the tube was removed on the third day, unless organisms were found, in which case the treatment was continued for ten days. Persistent sinuses were excised under an "umbrella" of parenteral penicillin and the limb immobilised in plaster until radiographic examination showed complete separation of the sequestrum which was then removed. Immobilisation was continued long enough to avoid the risk of fracture. Fourteen such cases have been treated with excellent functional and cosmetic results, with non-adherent scars and a remarkably short convalescence. Two chronic bone abscesses (Brodie's abscess) have been treated successfully by the same technique. Neither case gave a history of acute osteitis.

## DISCUSSION

In this series, the organism was penicillin-sensitive in every case. There were no deaths and only in case 9 do we expect any disability. Ten cases (three subacute) were treated successfully without surgical intervention. The incidence of sequestrum formation requiring surgical intervention is high (20 per cent) and it compares unfavourably with reports from other hospitals (McAdam 1945, Agerholm, Trueta, and Aird 1946). Sequestration may sometimes be inevitable, but with earlier diagnosis the frequency should diminish. In eighteen of the thirty cases pus was present under the periosteum or in the soft tissues when the patient was admitted to hospital. The real duration of illness is often difficult to assess and the figures given in Table II indicate only the duration of pain in the affected part. Moreover in all cases in which sequestration occurred there was severe infection with extensive raising of the periosteum. Nevertheless there were three errors in technique: 1) penicillin was sometimes discontinued too early, 2) Cases 11 and 14 were encased in plaster during the initial stage of treatment and tension was probably not relieved, 3) four incised wounds were left unsutured, and packing prevented restoration in continuity of the periosteum, during subsequent ward dressings penicillin-insensitive organisms were grown from these wounds on at least one occasion. In subsequent cases when the wound was sutured after incision and evacuation of pus, or after drilling of bone, there was healing by first intention and no sequestration. Wound suture after the relief of tension is the most important single step in preventing sequestrum formation (Agerholm and Trueta 1946). Drilling should seldom be necessary, but less harm will be done by bone-drilling followed by suture than by incomplete relief of tension. In two of three cases incised immediately after aspiration it was found that the evacuation of pus by aspiration had been incomplete. When pus is found under the periosteum, or in the soft tissues, it is clear that tension in the marrow cavity has already been relieved and bone drilling should be unnecessary. Guttering and saucerisation have no place in the modern treatment of acute osteitis. Arthritis in an associated joint has been satisfactorily treated by aspiration with or without local instillation of penicillin.

The dosage and duration of penicillin administration still presents problems. Garrod (1944) and Kolmer (1945) consider that inhibition of the standard staphylococcus in undiluted serum constitutes a therapeutic level. Bodian (1945) advocated a dose of 1000 units per lb. body weight per twenty-four hours by intramuscular injection. Buchanan (1946) found that such doses were insufficient to maintain a constant therapeutic level in the blood, and reported that 2000 units per lb. per twenty-four hours were necessary. Since less sensitive organisms than the Oxford staphylococcus might be encountered, we decided to use a daily dose of 5000 units per lb. body weight. Table III shows the dosage at present in use. It is similar to that recommended by Hudson (1946) and Agerholm and Trueta (1946).

The most economical method of giving penicillin is by drip transfusion into a muscle. Formerly this was our routine method of administration and Eudrip No. 3 appeared to be a satisfactory apparatus. However it was never popular with the nursing staff because: 1) an ill and restless child needs constant supervision to ensure that the needle remains in place, 2) the needle in the thigh causes discomfort and restriction of movement, older children stated their preference for intermittent injection, 3) the rate of flow is often difficult to control and after repeated sterilisation the apparatus requires more frequent attention, 4) despite reinsertion of the needle in new positions every second day, sterile abscess formation is not uncommon. Continuous infusion was therefore abandoned in favour of intermittent intramuscular injection. Intramedullary injection (Aird 1945, McAdam 1945) has not been used because of the risk of introducing penicillin-insensitive organisms, and because in older children it is difficult to penetrate the cortex of a long bone with a needle. The veins of a child are not suitable for continuous intravenous infusion and since adequate blood levels

are maintained by intramuscular injection, it is unwise to run the risk of thrombosis and infection from intravenous administration. Oil-wax suspensions are used only to give a complete night's rest; the injection is more painful than that of watery solutions, urticarial reactions occur, and in a small child frequent injections cause palpable and radiographic evidence of soft tissue thickening.

In earlier stages penicillin administration was stopped when septicaemia was controlled, and in twenty-two cases penicillin was given only for periods of nine to fourteen days (Table II). It would now appear, however, as the result of marrow cultures, and the reports of Aird (1945) and McAdam (1945) that fourteen days is the shortest safe period of administration, and in order to be sure of sterilisation of the bone we have continued administration for at least twenty-one days. This appeared to be adequate in Cases 24 to 30. Two methods of treatment have since been adopted. In both groups, intermittent injections were given for ten days (until septicaemia was controlled). In the first group, the bone infection was then attacked by a modification of the intermittent method of treatment of staphylococcal infections suggested by Bigger (1944) (2), shown in Table V. In the other group, penicillin was given in a dose of 100,000 units three times a day from the eleventh to the twenty-first day, this being based on experimental work on penicillin levels in bone cavities after sequestrectomy and conforming to the work of Florey (1946) on wounds. It is too early to report on the results of these methods.

TABLE V

SCHEME OF CONTINUOUS FOLLOWED BY INTERMITTENT PENICILLIN THERAPY

Days	Dose of Penicillin
1st to 10th	5000 units per lb per 24 hours
11th	No penicillin
12th and 13th	5000 units per lb per 24 hours
14th	No penicillin
15th and 16th	5000 units per lb per 24 hours
17th and 18th	No penicillin
19th and 20th	5000 units per lb per 24 hours

Until a more satisfactory explanation is given, we suggest that removal of the stimulus of continuing infection by sterilisation of the bone explains the absence of dense involucrum formation in cases of osteitis treated with penicillin. As a corollary, the appearance in the X-ray film of excess formation of new subperiosteal bone may indicate that the bone is still infected and that penicillin should be continued or the dose increased. Urticarial reactions occurred in four patients with chronic osteitis during a second course of penicillin. Another patient, receiving a second course, developed painful hydrarthrosis of the small joints of the hand. Sulphonamides have not been given to any case since penicillin became available, but we now intend to assess the value of combined penicillin-sulphathiazole therapy as suggested by Bigger (1944).

#### SUMMARY AND CONCLUSIONS

1. Acute osteitis as seen in a large children's hospital is described briefly.
2. Treatment of a series of cases of acute osteitis with penicillin is discussed under the headings of investigation, penicillin administration, surgical procedure, radiographic appearance and results. The findings are tabulated.

3. Recent investigations suggest that no time limit can be set to the duration of penicillin administration. At present routine marrow puncture appears to be the only certain method of control. We see no reason to alter the dosage set out in Table III. Administration should be continued until the marrow culture is sterile.

4. The methods adopted in subacute and chronic pyogenic bone infections are described separately.

All cases were treated in Mr Matthew White's unit at the Royal Hospital for Sick Children, Glasgow. I wish to express my gratitude for his constant advice and encouragement. I wish also to thank Dr Montgomery, Dr Guthrie and Dr Buchanan of the Pathology Department for their help and guidance in the attempt to solve some of the problems of penicillin therapy, and Dr Suttie for his interest and help in the interpretation of X-ray films.

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# PLASMA CELL TUMOURS

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This review is based on fifteen cases of plasma cell tumours which have been seen in recent years at the Westminster Hospital. In studying the widely different clinical features an attempt has been made to demonstrate various manifestations of this disease-process. The term multiple myelomatosis is used in this paper when a number of bones are involved. Single tumours are described as solitary plasmacytoma, either of bone marrow or of soft tissue according to their origin. An attempt will be made to correlate these newly reported cases with others already reported in the literature and in so doing to make a comprehensive classification of the disease.

## HISTORY

William McIntyre (1850) reported the first case of this condition under the name of *mollities ossium*. A microscopical report was given by Dalrymple, and Bence-Jones showed the presence of an unusual protein substance in the urine. Rustizky (1873) writing twenty-seven years later, has been credited with the first histological definition and seems to have been the first to recognise the disease as a specific affection of the bone marrow. Kahler (1889) is cited as the first to describe the clinical condition. Only the name of Bence-Jones remains from the original trio as being responsible for the discovery of a protein substance found in the urine in many cases.

Since that time numerous case reports have appeared in the literature, and good early reviews were made by Martin (1915), Wallgren (1920), and Geschickter and Copeland (1928). The disease was usually known as multiple myelomatosis, and at the time of Geschickter and Copeland's paper only five cases of disease in a solitary bone focus were to be found in the literature. Multiplicity of tumours was regarded as a cardinal symptom, and 90 per cent were shown to have involvement of ribs, sternum, clavicle, and lumbar spine.

More recently it has been shown (Cutler *et al* 1936, Willis 1941) that the condition often arises in a single focus which may reach considerable size before spreading to other bones. More cases have also been described where solitary tumours of bone remain without any other organ being involved.

A tumour, at first sight somewhat different from those described above, arising in the soft tissues of the nasopharynx but with a histological appearance similar to the bone tumour, is now recognised as belonging to the same disease group. Many of these cases have now been described, some remaining confined to soft tissues, and a smaller group associated with bone marrow tumours. Extramedullary soft tissue tumours have also been described outside the nasopharynx, and Hellwig (1943) who reviewed all extramedullary tumours reported since 1905 was able to find thirteen examples, the sites being the pleura, mediastinum, spermatic cord, thyroid, ovary, intestines, kidney, and skin. Gordon and Walker (1944) reported a case occurring in the lung, and Ulrich (1939) reported one arising in the testis.

Microscopically all these tumours, whether intra-medullary or extramedullary in position, are most commonly composed of plasma cells, the majority of which are mature, but with a certain number of intermingled immature forms. The histological details and cell types will be discussed later but mention of this point is made here in order to introduce the final and most rare variety of the disease in which plasma cells appear constantly in the peripheral blood, with or without associated bone tumours, but always with diffuse bone marrow infiltration of cells of the plasma cell type.

**Subgroups of the disease**—It is seen therefore, that various subgroups of the disease can be enumerated, and an attempt will be made to present our cases in such a manner as to demonstrate these groups

1 *Bone Marrow Tumours*—

- (a) Multiple at onset
- (b) Solitary at onset, with subsequent multiple spread
- (c) Solitary bone marrow tumours

2 *Extramullary Tumours*—

- (a) Confined to the nasopharynx
- (b) Primary in nasopharynx but associated with lymph node involvement
- (c) Primary in nasopharynx but associated with bone marrow involvement
- (d) Very rare examples occurring in other tissues, i.e., pleura, testes, skin, etc
- (e) Confined to the conjunctiva

(A somewhat doubtful group probably of granulomatous origin for examples see Hellwig 1943)

3 *Generalised Spread* (from 1 or 2 above)—

- (a) Spread to viscera, liver, spleen, etc
- (b) Plasma cell leukaemia

### Case Histories

**Case 1** J B, male, aged 60 years Under care of Dr S P Meadows Admitted to hospital December 13 1945 complaining of pain in chest and back between shoulder blades three months duration Two months before admission noticed tearing pain in chest associated with cracking sound as if a rib had broken This occurred twice For one week before coming into hospital aware of hard painless lump on left side of head During this week suffered several severe epistaxes *On examination*—Thin and pale Signs of congestion of bases of lungs Abdominal mass felt in right epigastrium Hard nodule felt over left temporal region and another just below left nipple both apparently attached to bone Patient's general condition very poor Went steadily downhill and died December 26 1945 *Investigations*—Radiographic examination showed clear oval areas in fourth and eighth right ribs and in third sixth seventh and eighth left ribs Body of eighth thoracic vertebra collapsed Bence-Jones protein found in the urine on several occasions *Post-mortem examination* *Skeleton*—One tumour found in calvarium lying over the vertex half-inch in diameter another seen in left temporal bone they were soft and purple on the cut surface Similar bony tumours, some more frankly haemorrhagic found in second third fourth fifth sixth, and seventh right ribs Masses all lay near the angles pathological fractures had occurred through each deposit The fifth and eighth left ribs showed similar appearances All vertebrae contained small haemorrhagic tumours Body of eighth thoracic vertebra collapsed and over its anterior aspect was a white fleshy tumour Sternum was fractured through the body and on section contained many similar deposits *Post-mortem examination* *Viscera*—All organs normal with the exception of *Trachea*—Reddened large laminated blood clot at the carina blocking both main bronchic lot showed organisation *Lungs*—Both lungs grossly oedematous bronchi contained fluid blood *Liver*—Weight sixty-eight ounces not obviously enlarged but many small white deposits both sub capsular and in depths of the organ *Spleen*—Weight seven ounces appeared normal to naked eye with exception of patchy capsular thickening *Cause of death*—Oedema of lungs following large epistaxis *Microscopic appearances*—*Ribs*—Tumours composed of masses of cells lying in scanty trabeculated stroma and completely replacing normal bone architecture the majority closely resembled plasma cells some binucleate and larger forms present *Liver*—The masses seen naked eye were composed of cells similar to those in the bone tumours (Fig 28) diffuse infiltration of plasma cells throughout the sinusoids *Spleen*—Some congestion groups of plasma cells seen lying in the sinuses (Fig 30)

**Case 2** W M, male, aged 52 years Under care of Mr E P Brockman First seen complaining of pain in back present six weeks *On examination*—General condition poor Radiographic examination revealed multiple clear-cut punched-out areas in skull ribs vertebrae femora and ill scattered diffusely throughout the bones *Investigations*—Bence-Jones proteinuria positive on numerous occasions Patient deteriorated rapidly died eight weeks after onset of symptoms *Post-mortem examination*—Cause of death—Scattered broncho-pneumonia Multiple small soft purple tumours found in bones enumerated above (Figs 1-2) No other abnormalities found *Microscopic examination* of tumours revealed masses of plasma cells in scanty but vascular stroma

**Case 3 C T**, male, aged 45 years Under care of Sir Stanford Cade First seen April 1932, complaining of intermittent pain and stiffness in the back progressing to severe pain and inability to bend forward Symptoms present two years *On examination*—Firm swelling found in the back just lateral to second and third lumbar vertebrae No loss of sensation or power in lower limbs Radiographic examination showed osteolytic process in second and third lumbar vertebrae but no other bone lesions *Treatment and subsequent history*—Forty-eight radon seeds each 1 millicurie inserted into the tumour by Sir Stanford Cade resulted in complete loss of pain and diminution in size of tumour Symptoms recurred September 1932 Radiographs then showed osteolytic lesions of punched-out type in skull fourth fifth, sixth seventh ninth and tenth right ribs sixth and seventh left ribs and right ilium (Figs 3-4) *Investigations*—Blood counts normal Repeated examinations for Bence-Jones protein always negative

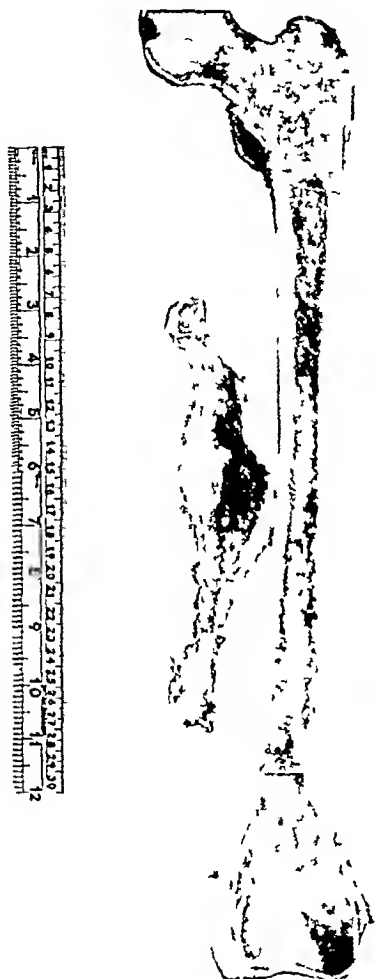


FIG 1

Case 2 Longitudinal section of femur and ilium showing multiple haemorrhagic deposits



FIG 2

Case 2 Longitudinal section of vertebrae showing haemorrhagic tumour and collapse of vertebral body with transgression of intervertebral disc

Biopsy of tenth rib November 2 1932 showed tumour composed entirely of cells morphologically similar to plasma cells both mature and immature (Fig 19) General health at this time reasonably good Patient discharged Remained well for some weeks when he began steady downhill course and died February 1933 three years after onset of symptoms No autopsy performed

**Case 4 J P**, female, aged 55 years Under care of Mr E P Brockman Admitted February 19 1947 complaining of pain in right arm Gave history of having fallen on outstretched hand six months previously Radiographs showed fracture of upper end of humerus passing through what was considered to be an osteoclastoma (Figs 7-9) *On examination*—No abnormal signs other than wasting of muscles round right shoulder girdle and a pulsating hard swelling fixed to bone over anterior aspect of upper end of humerus with a distended vein running over it All shoulder joint movements restricted Towards the end of February patient complained of pain in the low back Followed a downhill course and died March 15 1947 with left sided broncho-pneumonia and empyema *Investigations*—Wassermann and Kahn tests negative Blood counts normal Repeated tests for Bence-Jones proteinuria negative Radio

graphs at the end of February showed change in the tumour of the humerus towards an osteolytic appearance of malignant type. In the spine collapse of body of third lumbar vertebra noted. No other bone tumours found. *Post-mortem examination*—Left sided empyema confirmed and found to be extensive penetrating the interlobar septum underlying broncho pneumonia. At the base of the brain was a collection of green pus, similar in appearance to that in the chest spread had evidently occurred from the chest through site of twelfth thoracic vertebra which was collapsed and replaced by soft red tumour thus lying open the spinal canal. The third lumbar vertebra was also collapsed. Small red nodules seen in the majority of the vertebrae. No other tumours found except that in the humerus upper half of bone replaced by pink grey mass showing areas of haemorrhage with pathological fracture at lower end of lesion. Cut surface of sternum showed marked increase of purple appearance but no actual tumours. *Microscopic examination*—Tumours showed aggregations of cells, the majority with eccentric nuclei of typical plasma cell appearance binucleate and large forms common.

#### Case 5 P B, male, aged 41 years

Under care of Sir Stanford Cade. Complained of intermittent pain in right shoulder for three months becoming so severe that he could not lift his arm. Sleep impossible. *On examination*—February 1946 large firm slightly tender swelling under right deltoid muscle extending anteriorly across shoulder joint halfway along the clavicle and posteriorly across lateral border of the scapula. Tumour fixed to bone. Biopsy performed and diagnosis of plasmacytoma made (Fig 22). *Investigations*—Numerous tests for Bence Jones protein and albumen in the urine negative. Wassermann negative. Radiographs March 1946 showed multiple small round areas of decalcification in upper end of right humerus and acromion process (Fig 5). Multiple small areas of cortical destruction also extended down inner side of humerus. Considerable soft tissue swelling of whole shoulder region. Skull and other bones showed no other abnormality. Further radiographs May 27 1946 showed changes similar to those in the humerus in right ischium right inferior pubic ramus neck and greater trochanter left femur. One week later considerable thinning of anterior and posterior clinoid processes of the skull noticed. *Subsequent history*—General condition on admission very poor. Gave history of loss of weight up to the time of admission. Followed a downhill course while in hospital. Died June 22 1946. A few days before death further tumour noticed in skull just above right orbit. No autopsy performed.

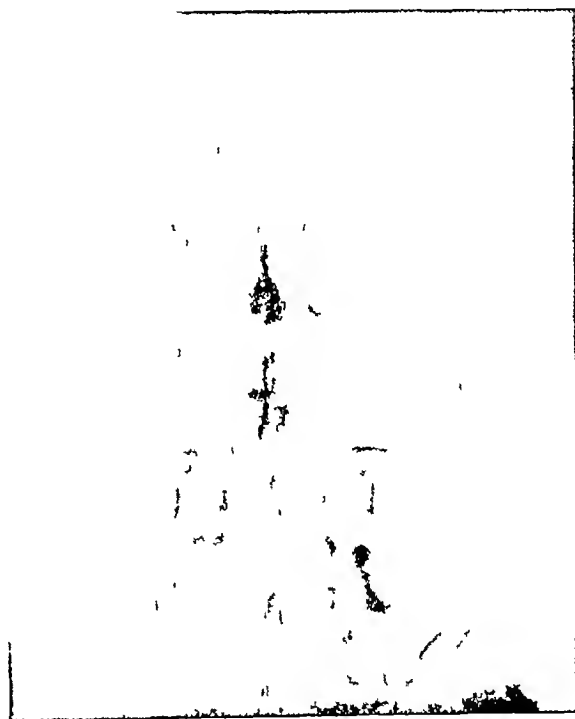


FIG 3

Case 3 Vertebral column showing destruction and collapse of second lumbar vertebra

#### Case 6 V B, female, aged 30 years

Under care of Sir Stanford Cade. First complained of pain in the back between shoulder blades 1942. Radiograph of spine at that time showed collapse of fifth and sixth thoracic vertebrae. Treatment for tuberculosis of spine by plaster jacket with periods of rest in bed (on one occasion for twenty months April 1942 to January 1944) continued until August 1946 when she developed motor and sensory loss of both lower limbs. December 1946 laminectomy performed including removal of large mass of red tumour material from region of fourth fifth and sixth thoracic vertebrae which were grossly eroded. Patient's condition not good enough to permit bone grafting plaster jacket applied. After operation weakness of lower limbs improved patient was able to move her legs, sensation returned. Admitted to the Westminster Hospital for radiation therapy January 18 1947. Microscopy of tumour showed typical plasma cells with large binucleate varieties (Fig 21). *Investigations*—January 23 1947—Plasma inorganic phosphates 6.3 mg per 100 c.c. Plasma urea 21 mg per 100 c.c. Serum alkaline phosphatase 6 units. Serum calcium 9.8 mg per 100 c.c. Thymol turbidity and flocculation tests negative. Serum albumen 5 g per 100 c.c. globulin 2.1 g per 100 c.c. total 7.1 g per 100 c.c. Repeated tests for Bence-Jones proteinuria negative. Proteose present precipitated by salicyl sulphuric acid not by heat. Wassermann reaction negative. *Radiographic examination*—Radiographs on six occasions between 1942 and the end of 1945 showed no skeletal lesion other than collapse of the thoracic vertebrae (Fig 10). On January 2 1946 a clearly demarcated osteolytic lesion was seen



in the neck of the left twelfth rib On February 21 1947 the following lesions were found in radiographs taken in Westminster Hospital multiple clear-cut punched-out areas of complete translucency in calvarium of skull (Fig 6) in fourth fifth seventh eighth, and ninth left ribs both pubic rami, upper end of right femur and both ilia *Subsequent history*—Patient is alive at present time and although she lies in a plaster case her general condition remains satisfactory

The importance of this case lies in the fact that it demonstrates the long time interval, in this instance four years, which may elapse between onset of the primary tumour and



FIG 4

Case 3 Radiograph of pelvis showing large deposits in the ilium

involvement of the bone marrow of many bones, with a radiographic appearance which is identical ultimately with that of typical multiple myelomatosis It should also be observed that Bence-Jones proteinuria was first noticed thirteen months after the second bone lesion and approximately at the same time as the development of multiple tumours This sequence of events shows that the diagnosis of a solitary bone tumour is justifiable only after a long follow-up period Willis (1941) stated that any bone marrow plasmocytoma remaining solitary for more than one year could be accepted as a true solitary tumour, but this case shows that it is not possible to give any specific time interval, and that all solitary tumours should be followed up for many years with the possibility of spread to other bones always in mind

symptoms pain so severe and persistent that he was unable to bear weight *On examination*—Smooth round hard swelling with ill-defined edges visible just below left greater trochanter fixed to femur but not to skin Hip movements full Biopsy performed Diagnosis of plasmocytoma made (Fig 13) *Investigations*—Serum alkaline phosphatase December 23 1946 December 30 1946 and July 8 1947—8 units Serum acid phosphatase December 23 1946—4.9 units (all alcohol-stable) Plasma inorganic phosphates December 23 1946—4.4 mg per 100 c.c. and July 8 1947—3.4 mg per 100 c.c. Serum calcium December 23 1946—10.3 mg per 100 c.c. and July 8 1947—10.2 mg per 100 c.c. On December 30 1946 serum proteins were raised albumen 4.8 g per 100 c.c. globulin 3.9 g per 100 c.c. total 8.7 g per 100 c.c. Thymol and colloidal flocculation tests positive 3 plus and 5 plus respectively On July 8 1947 after treatment all these values had returned to normal Serum proteins—albumen 4 g per 100 c.c. globulin 1.9 g per 100 c.c. total 5.9 g per 100 c.c. Flocculation tests negative Numerous tests for Bence-Jones proteinuria and albuminuria consistently negative Radiographs of all bones in the body December 22 1946 and January 6 1947 showed no abnormalities except in upper end of left femur where osteolytic changes in neck and trochanter extended slightly down the shaft (Figs 17–18) Repeat radiographic examinations January 16 1947 and January 24 1947 showed little or no change *Treatment and subsequent history*—Treatment undertaken with high voltage X-rays only using two ports of entry with skin dose 2000r to one and 2800r to the other Tumour dose 3000r General condition of patient while in hospital and during follow-up to present time has remained excellent Now has no pain what soever in leg

**Case 8 H N, male, aged 72 years** Under care of Mr E Stanley Lee History of slowly increasing pain in hips and legs and of solitary sacral tumour General health good for one year from onset of symptoms at which time uraemia developed Death three weeks later *Investigations*—Bence Jones proteinuria present each time a test was made during last two months of life but serum globulin was

never raised Wassermann reaction negative *Post mortem examination*—Diagnosis of solitary tumour of the sacrum confirmed by careful post mortem examination of entire skeleton and negative radiographic findings in all bones of the body excluding sacrum three weeks before death. Tumour of the sacrum large (8x8x6 cm) fleshy, replacing entire bone and undergoing central necrosis (Figs 15-16). Local invasion of posterior surface of rectum had occurred. *Microscopic examination*—Tumour composed almost entirely of typical plasma cells with some larger and binucleate forms lying in loose trabeculated matrix (Figs 11-12). Cause of death—uraemia following renal tubular block the association of which with myelomatosis will be discussed later (Figs 25-26).

The presence of Bence-Jones protenuria with a solitary tumour is most unusual and no other reference to it can be found in the literature. This case has been published in detail by one of us (Lumb, G, 1947).

**Case 9** E B, female, aged 66 years. Admitted to hospital March 1946 under Mr F Stanley Lee complaining of choking feeling in the throat for one year and difficulty in swallowing for three months. *On examination*—Large red nodular growth ulcerated at one point affecting right vallecula and extending across posterior third of tongue to left vallecula and laterally into pharyngeal wall on right side. No enlarged cervical glands. *Investigations*—Wassermann and Kahn tests negative. Blood count normal. Urine examination no abnormality. Biopsy April 8 1946. Tumour composed entirely of typical plasma cells. At the point of ulceration there was infiltration with inflammatory cells including polymorphs. *Treatment* by high voltage X-rays and teluradium total dosage 3100r to the tumour. In May 1946 mass had completely disappeared. Up to present time patient has been in normal health, no recurrence.

**Case 10** S F, male, aged 34 years. Under care of Sir Stanford Cade. January 1945 first complained of cough and dyspnoea not relieved by treatment. *Investigations*—March 1945 biopsy performed of small subglottic tumour 1 cm in diameter situated below posterior part of right vocal cord.

*Microscopic diagnosis* of plasmocytoma made. Wassermann and Kahn tests blood counts and urine tests all normal. After treatment by teluradium with tumour dose of 5000r mass disappeared and he remained well with no recurrence of symptoms until last seen February 1947. Then went to live in Edinburgh. We have received following report from Edinburgh Royal Infirmary. On examination of the larynx June 18 1947 when the patient reported complaining of increasing breathlessness for six weeks a swelling was seen in the subglottic region protruding into the lumen from the anterior wall. Dyspnoea increased and tracheotomy was performed later the same day. A piece of tumour was removed for biopsy and the histologist reported a plasmocytoma. A further

Case 5 Radiograph of right humerus showing multiple punched-out areas

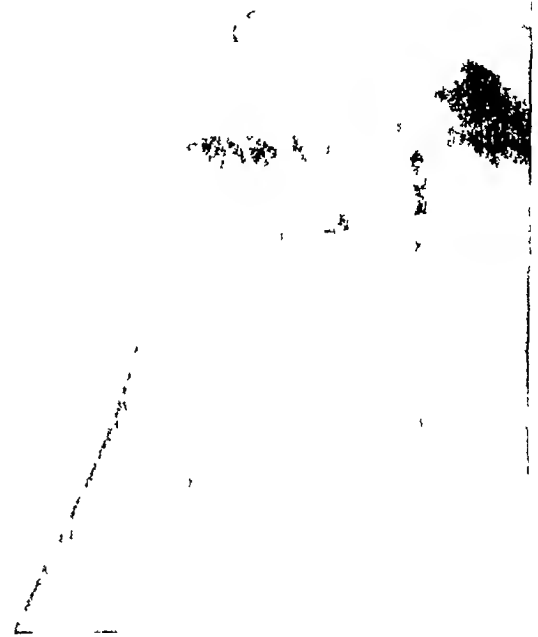


FIG 5



FIG 6

Case 6 Radiograph of skull showing multiple punched-out areas

course of irradiation is contemplated. Urine is still negative for Bence-Jones protein. [Radiographs of the entire skeleton show no bony tumours and there are no enlarged cervical glands. The patient's general health remains good.]



FIG 7

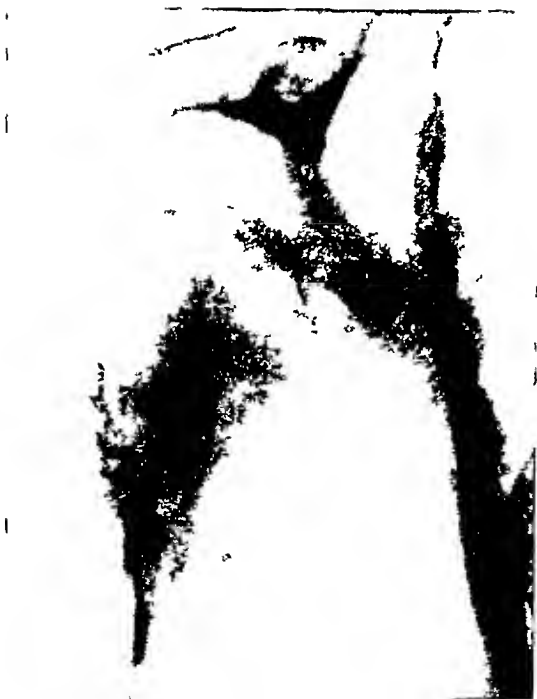


FIG 8



FIG 9

Case 4. Fig 7 is radiograph of right humerus showing a lesion resembling an osteoclastoma and including a pathological fracture. Fig 8 radiograph of same bone one month later shows osteolytic change in the lesion. Fig 9 four months after the original radiograph shows complete osteolysis.

**Case 11 Soldier, aged 20 years** Under care of Sir Stanford Cade and Dr F M Allchin History, seven years duration, huskiness and difficulty in breathing not severe enough to warrant treatment until January 1944 when thyrotomy was performed in the Army and a mass removed from right vocal cord Microscopic examination of this tissue showed sub epithelial accumulation of plasma cells but the general appearances were considered to be those of a chronic inflammatory process Repeated Wassermann tests negative No evidence of tuberculosis or leprosy Gram and Ziehl Neelsen staining of sections revealed no organisms Possibility of lichen planus excluded In succeeding years no definite diagnosis made Further small masses appeared so that March 12 1947 when seen for first time in Westminster Hospital he showed following lesions *On examination—Tongue*—Multiple cracks and fissures with induration and underlying firm areas *Palate*—Extending round labial aspect of teeth a red raised area firm and not tender From the hard palate extending on to the soft palate two raised firm non-tender red patches *Larynx*—Epiglottis and arytenoids thickened and the surface heaped up producing an appearance similar to that in the palate In right subglottic region further similar plaque of red rough heaped-up epithelium the lumen of glottis stenosed *Investigations*—Further biopsies from tongue and palate showed aggregations of plasma cells lying under epidermis A number of binucleate forms seen Clumps of cells infiltrated deeply but no invasion of epidermis and no ulceration (Fig 20) Sections stained Gram and Ziehl Neelsen showed no micro organisms, and in view of remarkable uniformity of cell type unusual in inflammatory changes it was considered that neoplastic origin was more probable Teleradium therapy in conjunction with high voltage X-rays instituted with tumour dosage of 5500r June 25 1947, all lesions had disappeared leaving only some oedema of arytenoids Urine tests for Bence-Jones protein repeatedly negative Serum proteins 7.5 g per 100 c.c. Blood chemistry in other respects normal

**Case 12 P E, female, aged 24 years** Under care of Sir Stanford Cade First complained March 1941 of swelling in left cheek and left side of face with difficulty in breathing through left nostril *Investigations*

—October 1941 Caldwell-Luc operation performed with extensive removal of soft growth in left lateral nasal wall Routine examination showed positive Wassermann and Kahn reaction Congenital syphilis diagnosed and anti-syphilitic treatment instituted Microscopy of the tumour showed it to be composed entirely of plasma cells and despite associated syphilis, the diagnosis of plasmacytoma was thought likely *Treatment and subsequent history*—Teleradium therapy instituted Radiographs showed

no bone tumours in skeleton Remained well and in October 1945 was delivered of normal child Wassermann test at this time negative and has remained so since Continued well until July 1946 when again developed epistaxis from left nostril with recurrence of soft tumour in left lateral nasal wall and antrum Readmitted to hospital September 1946 and further course of irradiation given October 23 1946 operation performed for removal of antro-nasal wall and ethmoid tissue including the tumour mass Microscopic examination showed tumour to be a plasmacytoma (Fig 24) Repeated tests for Bence-Jones proteinuria negative Has remained well until present time

**Case 13 G P, male, aged 44 years** Under care of Sir Stanford Cade and Dr F M Allchin First complained of sinusitis January 1944 at which time a nasal polyp was removed with complete relief until June 1945 *On examination*—Right side of nose obstructed with associated discharge and epistaxis *Investigations*—September 1945 Caldwell-Luc operation performed and numerous polypi removed Two months later epistaxis recurred January 12 1946 examination revealed friable bleeding mass arising

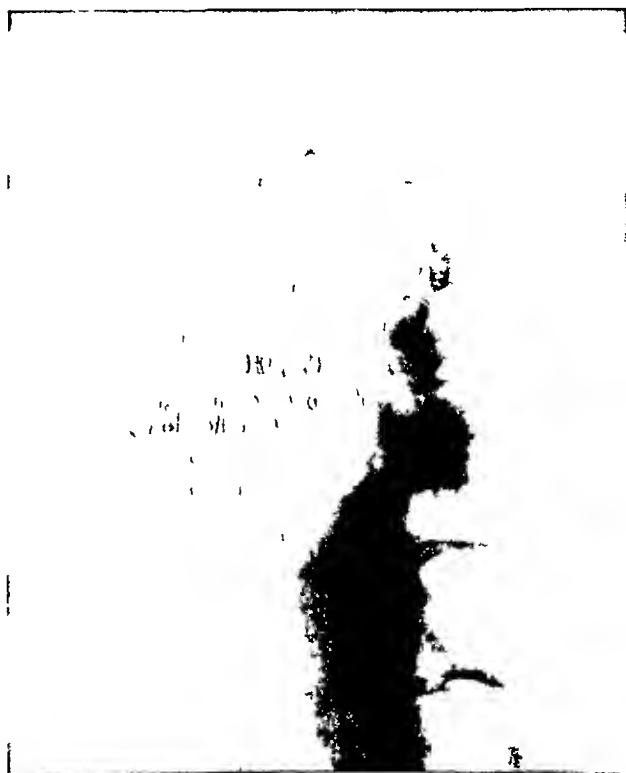


FIG 10

Case 6 Radiograph of spine showing complete osteolysis of thoracic vertebrae

from mid-meatal region causing depression of inferior turbinate bone January 28 1946, biopsy showed a tumour composed entirely of plasma cells (Fig 23) Repeated urine tests failed to demonstrate Bence-Jones protein After teloradium treatment with tumour dosage of 5450r, the tumour disappeared and patient was well until enlargement of upper deep cervical glands on right side occurred This swelling disappeared completely after further teloradium treatment, and patient remained well until November 1946 when he complained of left sciatic pain Radiographs of lumbar spine and

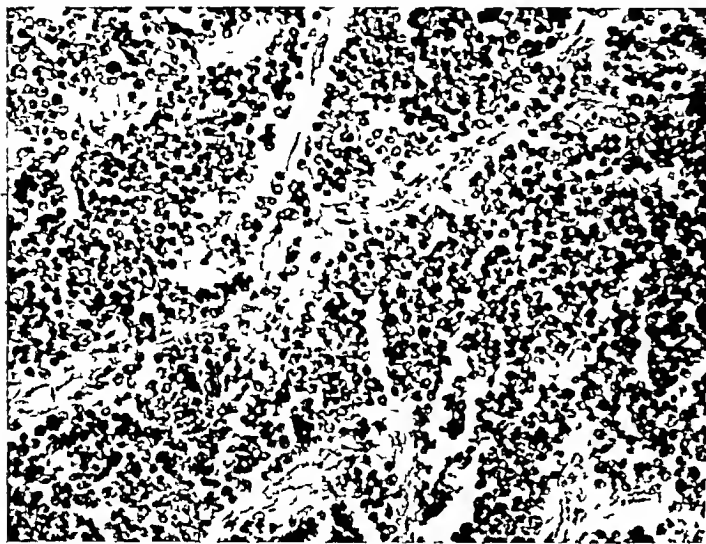


FIG 11

Case 8 Photomicrograph showing general trabeculated appearance of tumour Magnification  $\times 60$

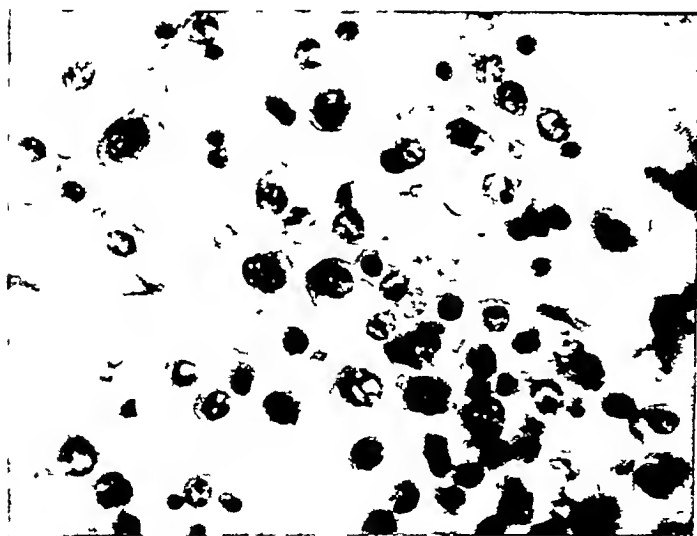


FIG 12

Case 8 High power view of same tumour as Fig 11 Magnification  $\times 240$

pelvis February 17, 1947 showed no bone lesions Patient went to South Africa March 1947 Rectal examination at this time showed no evidence of enlargement of prostate nor was there any clinical evidence of prostatic disease Patient admitted Groot Schuur Hospital in Capetown April 9, 1947, and they report general condition at this time poor deteriorated rapidly, complete paralysis with all signs of cauda equina lesion sensory loss to level of groins including saddle area, complete incontinence Left seventh and right eighth ribs showed swellings anteriorly with radiographic evidence of loss of bone structure and expansion Patient died May 4 1947 *Post-mortem examination* refused but one involved rib removed and showed microscopical evidence of plasma cell tumour Other investigations showed haemoglobin 13 g per 100 c.c., red blood corpuscles 3 490,000 per cu mm, white blood corpuscles 17,600 per cu mm neutrophils 78 per cent, lymphocytes 16 per cent, monocytes 2 per cent eosinophils 4 per cent No plasma cells seen Sternal marrow showed no abnormalities Lumbar puncture showed complete block—protein 140 mgm per 100 c.c., globulin increased one lymphocyte per 100 c.c. Blood chemistry normal Wassermann reaction negative Bence-Jones protein present in urine

Case 14 A G, male, aged 77 years Under care of Dr S P Meadows First seen November 1945, with six months history of shortness of breath and aching pain in chest Also had productive cough and indefinite abdominal pain Had lost two stones in weight during preceding two years *On examination*—Emphysematous with basal chronic bronchitis and slight oedema both ankles *Investigations*—

neutrophils 17 per cent, lymphocytes 22 per cent, monocytes 9 per cent, monoblasts 52 per cent. count of 500 bone marrow cells showed 30 per cent normal looking plasma cells (Fig 14). Distribution of other cell types normal. Urine tested repeatedly showed each time presence of Bence Jones protein and albumen. Blood protein November 12 1945—albumen 3.61 g per 100 c.c., globulin 3.82 g per 100 c.c., total 7.43 g per 100 c.c. and blood urea 42 mg per 100 c.c. Radiographic examination of the entire skeleton November 12 1945 November 30 1945 and December 7, 1945 showed no bone tumours. While in hospital patient's general condition became weaker and after gradual decline signs of right subdural haemorrhage appeared December 10, 1945. Died December 12 1945. *Post mortem examination*—Large subdural haematoma lying over right parieto-occipital region causing depression of underlying brain which was otherwise normal. Heart showed left ventricular hypertrophy but was otherwise normal. Liver weighed sixty-eight ounces, adherent to anterior abdominal wall over right lobe by old adhesions involving area two inches square. Spleen enlarged and congested. Several lymph nodes of coeliac and para-aortic group enlarged. Sternum ribs, vertebrae, and shaft of right femur showed hypertrophic purple marrow with oval cyst three quarters by half-inch containing soft purple marrow substance in neck of right femur. *Microscopic examination*—*Bone marrow*—Sections from various areas showed plasma cells of typical appearance in clumps among other marrow cells. *Liver*—Areas of fatty degeneration. Principle change was congestion of sinusoids all of which were wide open thus spreading liver cells apart. In the sinusoids apart from erythrocytes, were numerous typical plasma cells. Kupffer cells not generally enlarged but there were deposits of haemosiderin in some (Fig 29). *Spleen*—Congested. Occasional plasma cells seen in the sinusoids but no true invasion demonstrated. *Lymph node* from para-aortic group—normal architecture but sinuses widely distended and contained numerous plasma cells (Fig 31).

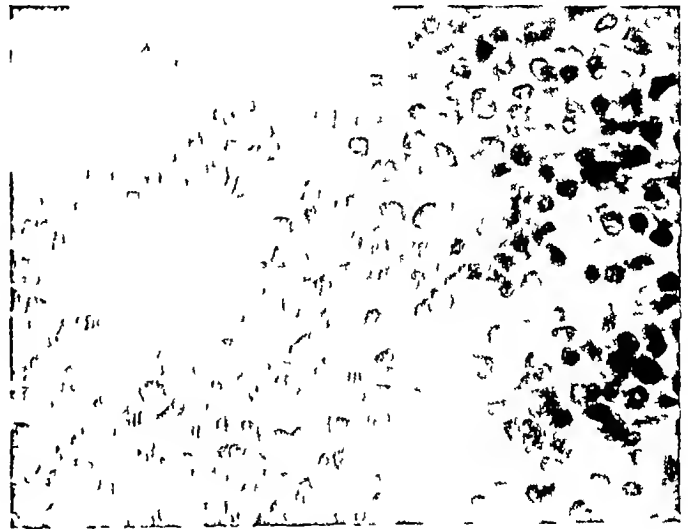


FIG 13

Case 7 Photomicrograph showing typical plasma cell appearance. Magnification  $\times 160$



FIG 14

Case 14 Photomicrograph showing high power view of sternal marrow smear. Magnification  $\times 800$

This case is most interesting in that despite the large number of plasma cells in the bone marrow and their presence in viscera such as the liver, spleen, and lymph nodes, the abnormal cells in the peripheral blood appeared to be monoblasts. This phenomenon is well recognised in other types of leukaemia where differing cell varieties appear in the marrow and the peripheral blood. The case may be described as an example of aleukaemic plasma cell leukaemia.



FIG 15

Case 8 Specimen of sacral tumour removed at autopsy showing complete destruction of sacrum and spread of tumour over anterior surface of right ilium



FIG 16

Case 8 Radiograph of pelvis showing osteolytic tumour destroying the sacrum

**Case 15** S. M., male, aged 57 years. First admitted under care of Dr W. E. Lloyd December 5, 1941, with one month history of dizziness, head pains, cough and pain left loin. *On examination*—Signs of bronchitis both bases. Liver and spleen palpable at two fingers breadth below costal margin. No lymph node palpable. Mass felt on left side in region of left kidney. *Investigations*—Urine contained albumen and Bence Jones protein. January 28, 1942, and gave positive results in numerous subsequent tests. Serum proteins January 30, 1942: albumen 5.1 g. per 100 c.c., globulin 11 g. per 100 c.c., total 6.2 g.



FIG 17



FIG 18

**Case 7** Radiographs of left femur showing solitary osteolytic lesion at upper end of the bone. Fig 17 antero-posterior projection. Fig 18 lateral projection.

per 100 c.c. Sternal marrow puncture January 27, 1942: 32.6 per cent plasma cells in a count of 500 cells. Despite this great increase in number of plasma cells the only other abnormality was relative reduction in erythrogenic tissue. Peripheral blood examination January 13, 1942: haemoglobin 62 per cent, red blood corpuscles 3,000,000 per cu mm, colour index 1.0, white blood corpuscles 7200 per cu mm, neutrophils 46 per cent, lymphocytes 35 per cent, monocytes 11 per cent, plasma cells 8 per cent. Blood examination January 26, 1942: haemoglobin 63 per cent, red blood corpuscles 3,150,000 per cu mm, colour index 1.0, white blood corpuscles 9200 per cu mm, neutrophils 36 per cent, lymphocytes 49 per cent, monocytes 5 per cent, plasma cells 10 per cent. Radiographs of lumbar and thoracic vertebrae showed no bone tumours. Renal function test on December 24, 1941: blood urea 36 mg. per 100 c.c., urea clearance test 57 per cent of normal. Patient was discharged February 16, 1947, and died shortly afterwards at home. Unfortunately no autopsy performed. Despite lack of post-mortem examination the diagnosis of myelomatosis is assured in view of the sternal marrow findings and it provides a good example of the rare condition of typical plasma cells occurring in considerable numbers in the peripheral blood (Fig 27) which may well be termed plasma cell leukaemia.

A resume of various points from the case histories is shown in Table I.



Case No	Sex	Age in yrs	Bones involved	Soft Tissues involved	Radiographs	Bence-Jones Proteinuria	Serum Protein		Survival
							Albumen	Globulin	
1	M	60	Ribs sternum vertebrae	Infiltration by plasma cells of sinusoids of liver and spleen	Punched - out areas in ribs and collapse of vertebrae	Repeatedly positive	—	—	3½ months
2	M	52	Skull ribs vertebrae femora ilium	None	Punched - out areas in affected bones	Repeatedly positive	—	—	2½ months
3	M	45	Skull ribs vertebrae right ilium	None	Osteolytic lesions in second and third lumbar vertebrae	Repeatedly negative	—	—	3 years
4	F	55	Humerus and vertebrae	None	Tumour in humerus first resembling an osteoclastoma later becoming osteolytic	Repeatedly negative	—	—	8 months
5	M	41	Humerus ischium skull	None	Multiple punched - out areas in affected bones	Repeatedly negative	—	—	10 months
6	F	30	Skull ribs vertebrae pelvic bones femora	None	Punched - out areas in affected bones	Unusual proteose present	5.0 g per 100 c c	2.1 g per 100 c c	Alive now after 5 years
7	M	48	Femur only	None	Osteolytic lesion at upper end of the left femur	Repeatedly negative	4.8 g per 100 c c in Dec 1946, 4.0 g in July 1947	3.9 g per 100 c c in Dec 1946, 1.9 g in July 1947	Alive now after 24 months
8	M	72	Sacrum only	Kidney (tubular blockage)	Large osteolytic lesion of sacrum	Repeatedly negative	5.1 g per 100 c c	2.5 g per 100 c c	13 months
9	F	66	None	Pharynx	No bone tumours	Negative	—	—	Alive now after 20 months
10	M	34	None	Larynx	No bone tumours	Negative	—	—	Alive now after 2½ years
11	M	20	None	Tongue palate larynx	No bone tumours	Negative	—	—	Alive now after 7½ years
12	F	24	None	Lateral nasal wall	No bone tumours	Negative	—	—	Alive now after 6 years
13	M	44	Ribs and vertebrae	Lateral nasal wall	Osteolytic lesions in ribs	Became positive after 3 years	1.8 g per 100 c c	2.0 g per 100 c c	3½ years
14	M	77	Diffuse infiltration of bone marrow	Liver, spleen and para-aortic lymph nodes	No bone tumours	Repeatedly positive	3.61 g per 100 c c	3.82 g per 100 c c	7 months
15	M	57	Infiltration of sternal marrow	Unknown	No tumours seen in lumbar and thoracic spine	Repeatedly positive	5.1 g per 100 c c	1.1 g per 100 c c	4 months

Note 1 — Plasma cells were found in the peripheral blood of Case 15

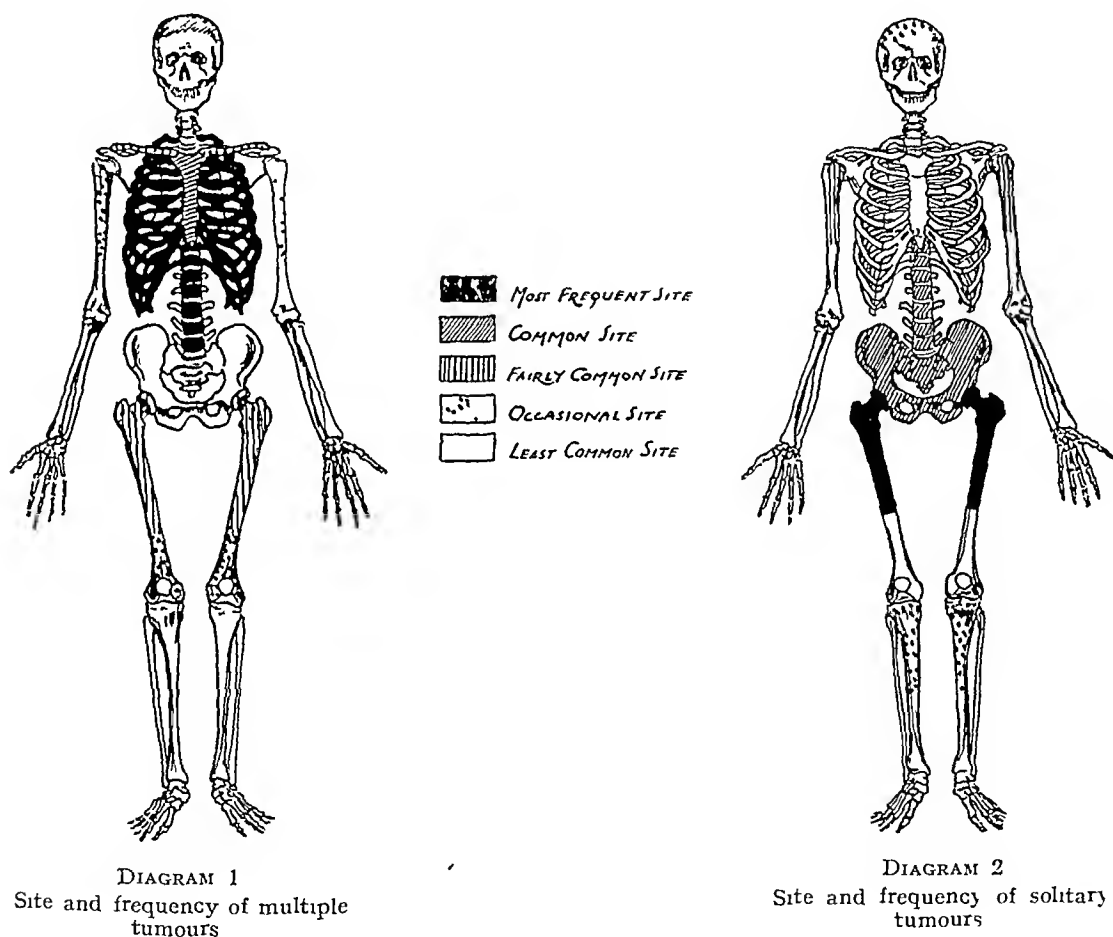
Note 2 — Wassermann reaction was negative in all cases except Case 12 which had a positive reaction for a period

Note 3 — Sternal marrow smears were examined in Cases 4 5 6 7 8 13 and 14 All were normal with the exception of 13 and 14 which showed 30 per cent 32.6 per cent of plasma cells respectively

## CLINICAL FEATURES

**Bone tumours—Incidence—**Multiple myeloma is the most rare malignant tumour of bone. The incidence is stated to be 0.03 per cent of all malignant disease (Geschickter and Copeland 1936) and it constitutes only 3 per cent of all bone tumours (Cade *et al* 1947). Solitary plasmocytoma of bone is even more rare, and in a search of the literature only seventeen proved cases have been found (Lumb 1947). In this series, of the seven cases of multiple myeloma five were males and two were females. This is in agreement with other recorded series which show a preponderance of males over females in the region of two to one. It is a disease of adult life, occurring usually between the ages of forty and sixty, but it can appear in young adults (Case 6). Kautman (1945) also reported a case of solitary tumour of the skull in a boy aged fourteen years.

**Site of multiple tumours—**In multiple tumours the flat bones are chiefly affected, especially the bones of the thoracic cage—ribs, vertebrae, sternum, and after that in order of frequency the skull, femora, pelvis and clavicle. Occasionally any bone may be



involved (Diagram 1). Any part of the spinal column may be the site of the disease. In this series there was one case with disease in the lumbar vertebrae and one in the dorsal vertebrae. The body and the processes of the vertebrae may be involved. At first the tumours are usually small, but occasionally they grow to the size of a pigeon's egg and sometimes become much larger (Case 4).

Bone tumours originate in the cells of the bone marrow, but it is important to realise that any site in the bone may be attacked. Round or oval clear-cut masses of grey or purple

tumour tissue appear. Multiplicity of lesions is characteristic of the condition. In the skull and ribs the tumours may be palpated or even seen. Larger tumours of course are plainly visible, more especially after they have transgressed the bone and involved soft tissues (Cases 4, 5, and 8). Indeed, in this condition so much bone may be replaced by tumour that pathological fracture occurs, and when tumours involve the vertebral column, pressure on the spinal cord may give rise to compression paraplegia (Case 6).

*Site of solitary tumours*—Solitary tumours tend to be larger than any individual mass of the multiple disease. Moreover the order of frequency of bones affected is different (Diagram 2). Thus of eighteen proved cases in the literature, six were in the femur, five of which were in the upper third (Zdansky 1927, Martin *et al* 1928, Rogers 1929–30, Harding and Kimball 1932, Rutishauser 1933, and Case 7 in the present series), four were in the vertebral column (Walthard 1924, Cutler *et al* 1936, Willis 1941, Lumb 1947), four in the bones of the pelvis other than the sacrum (Cutler *et al* two cases 1936, Leedham-Green *et al* 1938–39, Gootnick 1945), two were in the humerus (Shaw 1923, Stewart and Taylor 1932), and one each in the tibia (Chesterman 1935–36) and the skull (Kaufman 1945).

*Differentiation of solitary tumours from generalised disease*—In assessing cases which can truly be termed solitary plasmocytoma of bone, we agree with the criteria for diagnosis laid down by Willis (1941). Thus the possibility that the tumour is merely an initial sign of generalised disease must be excluded. This may call for observation over several years (Case 6). We believe that all solitary tumours should be held suspect and that careful follow-up should be continued indefinitely. Other important features in diagnosis are histological examination of the tumour, repeated radiographic examination of all bones in the body and repeated tests for Bence-Jones proteinuria. If all these factors are insisted upon, a very large number of cases reported in the literature as solitary tumours must be excluded. It is in this way that we have arrived at our total of eighteen proved cases.

*Symptoms and signs of bone tumours*—The local symptoms and signs of tumours, whether single or multiple, are identical and can be discussed together. *General symptoms* are found only when the tumours are multiple. An exception is to be noted however in Case 8 which is most unusual, and so far as we can discover the only example of its type so far described (Lumb 1947). *Pain* is without doubt the most frequent symptom. In the majority of cases pain is also the earliest manifestation. In our cases of bone disease it occurred without exception and in all it was the first symptom. It may, however, occur only after injury, which is often trivial but which may lead to pathological fracture of an already diseased bone. Ulrich (1939) states that from a study of the history of 259 cases of multiple myeloma there was freedom from pain in only 4.6 per cent, while clinical recognition of the tumour was possible in 36.7 per cent. The onset of pain is insidious and often intermittent, becoming gradually more severe and continuous. This is well marked in most tumours of the spine. It should be noted that pain may precede the appearance of a tumour by many months (Cases 3, 7, and 8). In the later stages of the disease there is general *malaise*, weakness, and anaemia, progressing to *cachexia*. During this period the pain becomes increasingly widespread and severe. *Anaemia* may be an important concomitant, doubtless due to extensive bone marrow replacement. Occasionally, unexplained anaemia may lead to bone marrow investigation and radiographic examination with recognition of the condition. *Complications*—The usual complications of the disease are pathological fracture of a bone, and compression paraplegia in the case of vertebral tumours.

*Extra-medullary plasma cell tumours*—*Incidence*—These tumours, although occurring with greater frequency than solitary plasmocytomata of bone, are nevertheless rare. In the great majority of cases they arise in the larynx, air sinuses, and upper air passages. They may easily be mistaken for the much more common, and more grave carcinomata and sarcomata which arise in this situation, or they may be mistaken for chronic inflammatory conditions. Of our cases, three were males and two were females. In other reported series

there has been an even greater preponderance of males, ranging from five to one, even up to thirteen to one (Hellwig 1943). It is a disease of adult life, usually reported between the ages of forty and sixty, but two of our cases were less than twenty-five years of age.

*Site*—The tumour occurs most frequently in the mouth and upper air passages. All our cases have been in this situation, one in the subglottic area, two in the lateral nasal wall involving the inferior turbinate bone, one in the vallecula, and one involving the tongue, palate, and larynx. Hellwig (1943) reviewing 127 cases from the literature found sixty-three in the air passages, forty-seven in the conjunctiva, four in the lymph nodes, and thirteen in other organs—the pleura, mediastinum, spermatic cord, thyroid gland, ovary, intestines, kidney, and skin.

**Symptoms and signs of extra-medullary tumours**—When the tumour is in the nasal passages the classical symptoms are 1) nasal obstruction, 2) discharge from the nose, 3) epistaxis, 4) tumour in the nose, 5) deformity of the nose, face, or palate, 6) pain. Of these, the first three are cardinal symptoms of the disease. The discharge at first is clear and watery, becoming thicker and purulent, and later blood-stained. *Epistaxis* may be repeated and severe. In both our cases of nasal tumour it was an early symptom. *Deformity* depends upon the position of the tumour and the direction of spread. One of our cases (Case 12), in which the growth had extended forwards, showed swelling of the cheek. The tumour may involve the antrum, spread backwards into the nasopharynx or pterygo-maxillary region, grow upwards displacing the nose or eye, or downwards to present in the roof of the mouth. *Pain* is not a common symptom in the early stages but indefinite dull aching in the region of the growth is frequent, and in both our cases a provisional diagnosis of "sinusitis" had been made. When the tumour is situated in the larynx *hoarseness* and *dyspnoea*, with or without cough, are invariable symptoms.

*Clinical appearances*—Examination of the nose reveals a red, friable, often ulcerated, and partly necrotic, bleeding mass, obstructing the airway, without biopsy it is sometimes very difficult to differentiate from carcinoma of the antrum. We have observed that the vascularity of the plasmacytoma group tends to be greater than in the case of other tumours occurring in this area. When tumours are found elsewhere than in the upper air passages the clinical appearances are much the same. Soft, red, polypoid tumours are found (Case 10). Sometimes there is an associated submucous thickening of the nasopharynx, epiglottis, and larynx, with subsequent stenosis (Case 11, and Vogt 1912, quoted by Blacklock and Macartney 1932). It should be stressed that these tumours may be single or multiple in their distribution. Thus in our series Cases 10, 12, and 13 were single, and case 11 was multiple.

*Clinical course*—It has been indicated (Stewart and Taylor 1932, Blacklock and Macartney 1932, and Hellwig 1943) that these tumours may follow various courses: they may be completely benign and without recurrence, they may show local malignancy in the form of invasion and destruction of adjacent tissues, and a tendency to local recurrence following treatment, and finally cases have been described where invasion of adjacent lymph nodes has occurred with ultimate bone involvement indistinguishable from multiple myelomatosis (Case 13).

## RADIOGRAPHIC APPEARANCES

**1 Multiple myelomatosis**—In typical cases the tumours produce multiple circumscribed areas of destruction involving both cortex and medulla, in which the bone texture has completely disappeared. The lesions occur in any part of the bone and typically they are found in vertebrae, ribs, sternum, and skull, eventually affecting any or all bones of the skeleton (Diagram 1). The areas appear as clear-cut, punched-out, oval or round patches of complete translucency, from 1 to 3 cm in diameter, a characteristic feature being the lack of new bone formation either in the bone itself or in the periosteum. Fractures, and when

the lesion is in the vertebrae—areas of collapse, are common. Collapse of vertebrae occurs at an early stage and is associated with destruction of the intervertebral disc, in contrast to metastatic carcinoma where collapse occurs later and the discs are not involved. Kyphotic deformities are frequent, and differentiation from tuberculosis of the spine may be difficult in so far as this disease is also characterised by destruction of the intervertebral disc. Deficiencies in the skull often simulate those seen in xanthomatosis, but this condition is most frequent in children and young people, and the deficiencies have an irregular outline forming "map-like appearances". Translucent areas in the skull are also found in osteomalacia and osteitis fibrosa which must be excluded.

**2 Solitary plasmacytoma**—Solitary plasmacytoma of bone marrow, and multiple tumours beginning in solitary foci, may be considered together from the point of view of radiographic appearances. Two different types of lesion have been described, the histological appearances being identical (Gootnick 1945, Paul and Pohle 1940). The first type is cystic and trabeculated, closely resembling an osteoclastoma. The lesion is large, of reduced density and sharply limited, within it are thickened irregular trabeculae. It is usually found in the medullary portion of the pelvis or long bones, frequently expanding the cortex. There is often pathological fracture (Figs 7, 8, 9). The second type of lesion is purely destructive and very similar in appearance to the osteolytic metastasis of a carcinoma, or an osteolytic type of osteogenic sarcoma. It is sharply demarcated, homogeneously rarified in appearance, and seldom shows expansion. The vertebrae are often involved (Figs 10, 16, 17 and 18).

In our series, Case 4 was an example of the first type. This variety is the more rare form of tumour. Cutler *et al* (1936) describe one case, and Gootnick (1945) reported another. Paul and Pohle (1940) suggested that in the case of a solitary tumour with these radiographic changes the prognosis is better than in other varieties. This has not been our experience, for in Case 4 which was of this type, death occurred within seven months of the onset of symptoms. Examples of the second type of radiographic appearance are seen in cases 5, 7, and 8, showing bone lesions which were purely destructive, and with marked osteoporosis or complete lysis of a large area of the involved bone, with no evidence of new bone formation either within the bone itself or under the periosteum. This appearance may be extremely difficult to differentiate from that of other destructive lesions of bone.

Radiographic examination, therefore, although of the utmost importance in the diagnosis of solitary and multiple myelomatosis, cannot be said to be pathognomonic for all cases.

### DIFFERENTIAL DIAGNOSIS

Soft tissue plasma cell tumours in the upper air passages must be distinguished from carcinoma and sarcoma with which they can easily be confused. The degree of vascularity of the plasmacytoma seems to be the most significant clinical differential feature. Biopsy with microscopical identification of plasma cells can exclude the more malignant condition but the differentiation of chronic granulomatous diseases may be difficult. (See *Microscopic Examination of Tumours*, on opposite page.)

The differential diagnosis of plasma cell tumours in bone must include all the bone lesions, it is of primary importance to decide whether the tumour is solitary or multiple. Radiographic appearances are not pathognomonic. In fact no single diagnostic point is infallible and it is only when clinical appearances, radiographic changes, microscopic and biochemical evidence, are considered together that the positive diagnosis can be made.

No mention has been made of those rare examples where the disease occurs in some other soft tissue or viscus, because the differential diagnosis is essentially that of the particular organ involved.

## MORBID ANATOMY AND MICROSCOPY OF TUMOURS

The tumours are soft, mainly red or purple in colour, very vascular, and bleed freely when cut. When large in size, central necrosis may take place (case 8). When the tumour is situated in the bone marrow local invasion causes thinning of bone and ultimately pathological fracture. Soft tissue tumours, either of primary origin, or after bursting the boundaries of the bone, show local invasion of surrounding structures such as muscle, mucous membrane, or even skin.



FIG 19

Case 3 Low power view to show erosion of bone Magnification  $\times 60$



FIG 20

Case 11 } Low power view of soft tissue tumour lying beneath squamous  
          } epithelium but not invading it Magnification  $\times 60$

The microscopic appearances of the tumours described in our series are so essentially similar that they can be discussed together. The commonest cell type in all cases measured ten to fourteen microns in diameter and was ovoid, polygonal, or pyriform in outline, with a nucleus containing a well-marked nucleolus, and often eccentrically placed. The nuclei were

composed of dense chromatin, arranged in masses around the periphery to give a "cart-wheel" or "clock face" appearance. A perinuclear halo, best demonstrated when stained with iron haematoxylin, was seen in many cases. The cytoplasm was plum-coloured when stained with eosin, and in some cases a carmine colour was produced with pyronin methyl green (Cases 8 and 12). Difficulty was experienced in the majority of our cases in obtaining positive Pappenheim reactions with pyronin methyl green. In this connection Geschickter and Copeland (1928) state that "these cells do not take the typical plasma cell stain by the Unna Pappenheim or polychrome methylene blue technique". Morison (1941) also failed to obtain positive results in myelomatosis with the Unna Pappenheim method. Stewart and Taylor (1932), however, obtained typical results in four cases. It would appear, there-

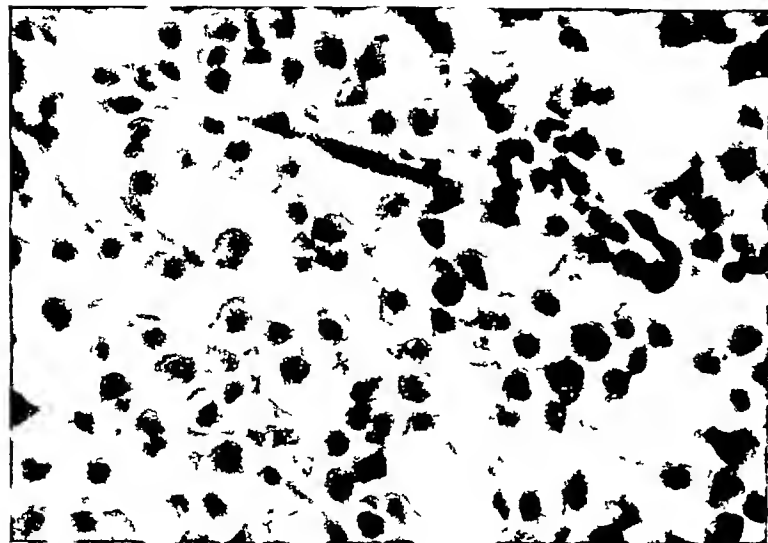


FIG 21

Case 6 Photomicrograph showing trabeculated tumour. Magnification  $\times 160$

fore, that although the commonest cell type in these tumours has all the morphological characteristics of the plasma cell, it does not always react in the same way as the inflammatory variety of cell to pyronin methyl green staining.

In addition to the cells described above many larger forms, frequently with two or more nuclei were seen (Figs 12 and 24), but these cells always retained an essentially similar general nuclear structure and are regarded as of similar origin. Mitotic figures were not frequent in our series but were found in small numbers in the majority of cases. Cells tended to remain discrete in most areas but were sometimes closely packed together. The stroma was invariably scanty, consisting of fine trabeculae interspersed with numerous small blood-vessels. Histological evidence of invasion could be obtained in all cases where spread occurred and examples of muscle and bone invasion are seen in Figs 22 and 19.

In Case 4 the greatest variation from plasma cell type was seen, and some difference of opinion might exist as to whether this case of myelomatosis should be classed as of "plasma cell type". Ewing (1940) used the term "myeloma" to describe tumours arising from specific bone marrow cells, and recognised the following types histologically: 1) plasma cell myeloma, 2) myelocytoma,



FIG 22

Case 5 Low power view of tumour to show invasion of muscle fibres. Magnification  $\times 60$

derived from granular leucocytes, 3) lymphocytoma, derived from lymphocytes, and 4) erythroblastoma, derived from nucleated red cells. Whether any such clear-cut differentiation is justifiable is not fully established.

Some authors have attempted to differentiate the cell types by means of the peroxidase staining reaction (Beck and McCleary 1919) and others by means of the Unna Pappenheim reaction (Aschoff 1905). Many authors, in describing different cells in cases of multiple myelomatosis, have been uncertain whether to class them among the plasma cell or the myelocytic group, and some have thought the apparent difference was due to fixing or staining methods (Berblinger 1911, Shennan 1913).

Christian (1907) in a most careful histological description of six cases, felt that the tumour cells showed a greater resemblance to plasma cells as found in the bone marrow than to any other type of cell, and concluded that a group could be defined within which the cells of individual cases showed no greater variation than occurs in other tumour groups. This belief has been confirmed by most workers in later years and is borne out by the cytological findings in our series.

It may be noted that in recent years the number of reports of plasmocytoma, as compared with other types, has increased.

Wallgren (1920) found only three cases reported as plasmocytoma out of twenty-five cases reported between 1900 and 1904, whereas fifteen cases out of thirty between 1905 and 1909, and fifteen cases out of twenty-five between 1910 and 1914, were labelled plasmocytoma. Fleischhacker and Kline (1936) diagnosed nine of their ten cases as plasmocytoma with the remaining one doubtful. Similarly in most other reports this tendency is noticeable, whilst in accounts of soft tissue tumours, cells histologically

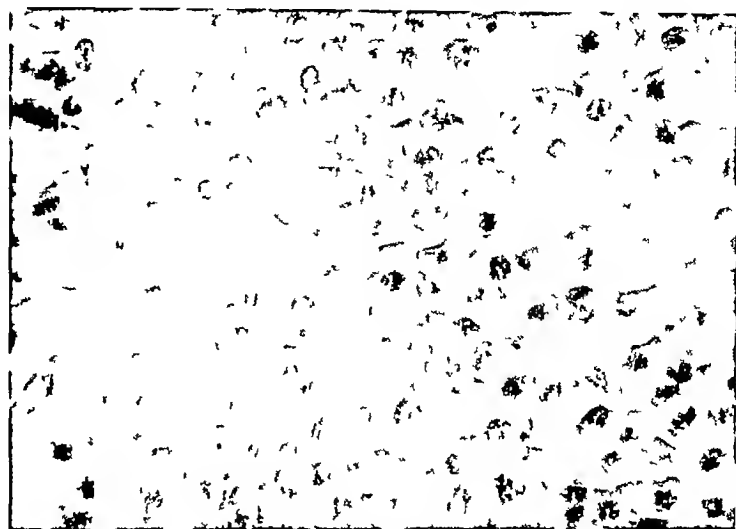


FIG 23

Case 13 Soft tissue tumour showing plasma cells some large and some binucleated. Magnification  $\times 160$

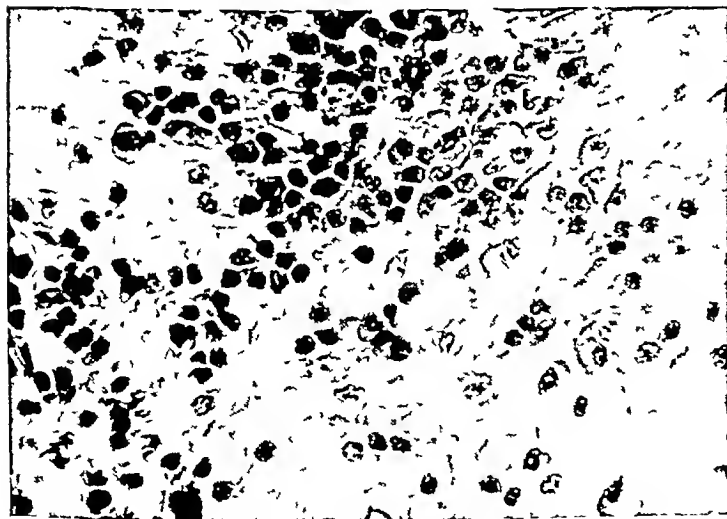


FIG 24

Case 12 General view of soft tissue tumour. Magnification  $\times 140$

resembling plasma cells have always been described, and in our series this finding was confirmed.

Microscopic evidence of the degree of malignancy in these tumours is usually estimated by the degree of variation of cell type, the frequency of mitotic figures, and evidence of local



invasiveness. It is true that in our cases which showed multiplicity these features were more marked than in the solitary cases.

Many authors have thrown doubt on the truly neoplastic nature of the nasopharyngeal tumours which remain confined to their site of origin. It has been argued that the plasma cell is commonly seen in chronic granulomatous conditions, and that an inflammatory etiology is likely. In this connection our Case 11 may be cited, because in this patient a granulomatous origin was considered seriously. This case closely resembles one reported by Blacklock and Macartney (1932) and we draw the same conclusion, namely that, in view of the uniform cellular pattern, the absence of organisms, and the failure to invade the surface epithelium, a neoplastic origin is the most likely (Fig 20). This fact is further substantiated by rapid disappearance of the tumours after irradiation.

### BIOCHEMICAL FEATURES

**Bence-Jones proteinuria**—Since the discovery by Bence-Jones in 1848 of an unusual substance of protein nature in the urine of patients suffering from multiple myelomatosis, considerable importance has been attached to its presence as a diagnostic feature of the disease. Bence-Jones protein is precipitated below 60° C but disappears on boiling, only to reappear on cooling again to 50°–60° C. It may be separated from albumen, also present so frequently in the urine of myelomatosis cases, which starts to come down at 70° C and flocculates at 80°–100° C. Care should be taken in testing for Bence-Jones proteinuria to use filtered urine, the pH of which has been made neutral or faintly acid.

While the presence of this protein substance in the urine is a strong indication of multiple myelomatosis, it must be remembered that Geschickter and Copeland (1928), surveying a large number of cases, found the test positive in only 65 per cent. Hellwig (1943) found 61.8 per cent positive in a series of 259 cases which he reviewed. Moreover Bence-Jones proteinuria has been reported on rare occasions in other conditions, notably metastatic carcinoma in bones, multiple bone sarcoma, senile osteomalacia, fibrocystic disease of bone, chronic lymphatic and myelogenous leukaemia, and polycythaemia rubra vera (Bayrd and Heck 1947).

It has usually been stated that in solitary plasmocytoma of bone Bence-Jones protein does not appear in the urine, and this is true of the majority of cases. In our series, however, Case 8, a proved solitary tumour, gave positive tests for Bence-Jones protein on numerous occasions. It is our view that the presence of this substance in the urine may well be associated with the total bone marrow involvement by tumour. In Case 8 a very large mass was present. No record of Bence-Jones proteinuria has been made in cases of soft tissue tumours without bone involvement, a fact borne out in our series.

**Abnormal serum protein**—Ellinger (1899) first recorded abnormal protein, precipitated by heat at 56° C, in the serum of myelomatosis cases. Since then frequent reports are available of raised serum protein, in one example the figure being as high as 18.4 grammes per 100 c.c. (Atkinson 1937). It is generally considered that the protein appearing in the serum is of the same chemical composition as the Bence-Jones protein found in the urine, although in referring to our own cases, and those in the literature where tests for both substances were recorded, no correlation between blood protein and the presence or absence of Bence-Jones proteinuria can be made.

Blackman *et al* (1944) have shown that the abnormal protein is a globulin, and they have thought it most likely to be a beta globulin. The positive flocculation tests in one of our cases (Case 7) suggest the possibility of a gamma globulin also playing some part in the make-up of the substance. Gutman *et al* (1941) have shown that the globulin does not react in the usual way to the salting-out process used for estimating the albumen and globulin fractions in the total serum protein. Thus abnormally high albumen or globulin fractions may

be recorded, or on the other hand normal or even apparently reduced levels may be found. These findings have been borne out in our series.

Certain blood changes thought to be associated with the abnormal serum protein have been recorded. Stewart and Parkes-Weber (1938) noted failure of clot retraction, auto-haemagglutination, increased viscosity, accelerated erythrocyte sedimentation rate and spontaneous thrombosis.

**Amyloidosis**—The association of amyloidosis with multiple myelomatosis has frequently been noted. Magnus Levy (1931) reported the phenomenon, Atkinson (1937) collected forty cases from the literature, and Blomberg and Fischbach (1945) reported one other. Amyloid

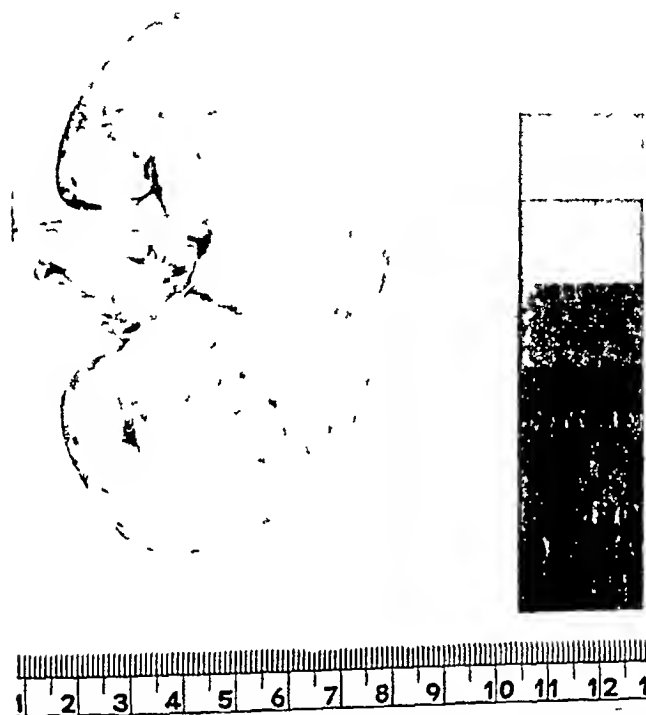


FIG 25

Case 8 Kidney removed at autopsy showing surface pallor with haemorrhagic splashes

substance is deposited through the body and has been noted particularly in the kidneys. It does not always give typical staining reactions, and has been considered as being produced by abnormal protein metabolism following myelomatous permeation of the marrow. We have no case associated with amyloidosis, but an example already fully reported by Stewart and Parkes-Weber (1938) was under the care of Sir Stanford Cade in the Westminster Hospital. In this case the amyloid deposits were found in particular around the joints.

#### KIDNEY CHANGES

Renal changes in multiple myelomatosis have been described (Lohlein 1921, Bell 1933, Forbus *et al* 1935, Holman and Hill 1939, Morison 1941, and Newns and Edwards 1945). Bell studied eleven such cases. All authors describe tubular blockage as the principle lesion. Glomerular changes are minimal or absent, and the general appearances are similar to those found in the acute uraemia of crush anuria, mismatched transfusions, and sulphonamide poisoning. The substance blocking the tubules is thought to be Bence-Jones protein. Blackman *et al* (1944) brought evidence to show that albuminuria does not damage the tubules.

invasiveness. It is true that in our cases which showed multiplicity these features were more marked than in the solitary cases.

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low total leucocyte count. However, the generalised nature of the disease, and its course, are similar to that seen in other leukaemias. This group of cases simply demonstrate one of the many varieties possible in an essentially multifocal disease, and the use of the term leukaemia is of value only as a reminder that generalised blood invasion can occur.

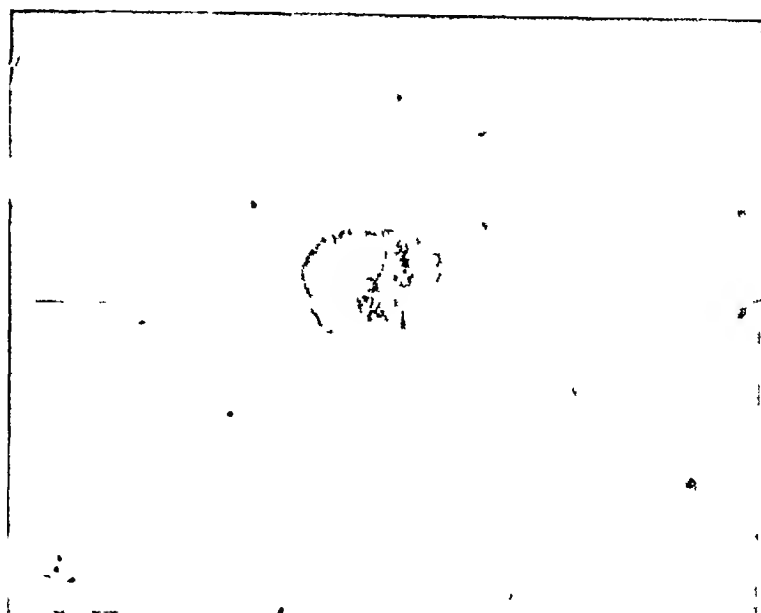


FIG 27

Case 15 Photomicrograph of peripheral blood smear showing a typical plasma cell. Magnification  $\times 800$

**Plasma cell invasion of liver and spleen**—In myelomatosis with peripheral blood involvement it is common to find plasma cell invasion of such organs as the liver and spleen. Lymph node infiltration is seen and in fact any organ may be involved. In our Case 14, liver and lymph node invasion was well demonstrated (Figs 29 and 30) but although at autopsy the spleen was seen to be enlarged and congested, no true plasma cell invasion could be demonstrated microscopically. Spleen invasion was seen in Case 1 (Fig 30).

#### TREATMENT AND PROGNOSIS

When it has become multiple, treatment of the disease can be only palliative, for a fatal termination is inevitable. The duration, when multiple invasion of bones has occurred, varies. Geschickter and Copeland (1928) quote two years as the average. In our series four patients (Cases 1, 2, 4, and 5) were dead within months, while Case 3 lived for three years. Case 6 is interesting in that four years elapsed before the bone tumours became multiple and she is still alive and in good general health five years after the onset of disease, and one year after the development of multiple tumours. Individually the tumours are very radio-sensitive, and irradiation with high voltage X-rays or radium provides the only useful form of therapy, 2500 to 3000r is delivered to each tumour treated over a period of three to four weeks. In order to avoid skin damage two or more ports are used, employing fractions of 150 to 200r at each treatment. After such a course of therapy, there may be radiographic evidence of regression of tumours with areas of recalcification. Treatment is particularly valuable when applied to the spine. The pain and discomfort of compression paraplegia may be obviated if treatment is given before vertebral collapse occurs, or alleviated if it is given later. The relief of pain is often very dramatic.

For solitary tumours some authors have claimed the merits of surgery, either alone, or followed by irradiation, as an alternative to irradiation alone. Thus Stewart and Taylor (1932) reported a case with a successful eight-year follow-up after forequarter amputation

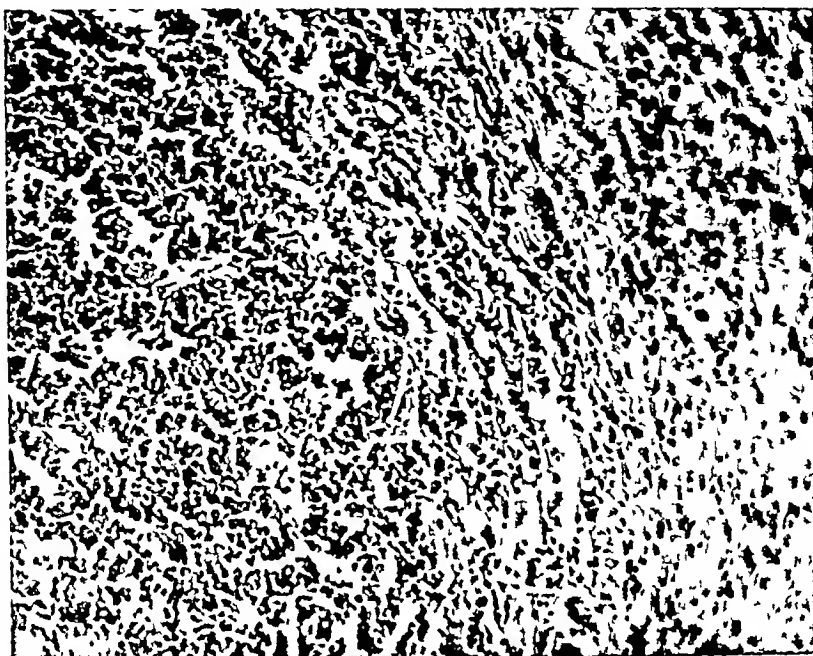


FIG 28

Case 1 Photomicrograph showing nodule of plasma cells lying in the liver Magnification  $\times 60$

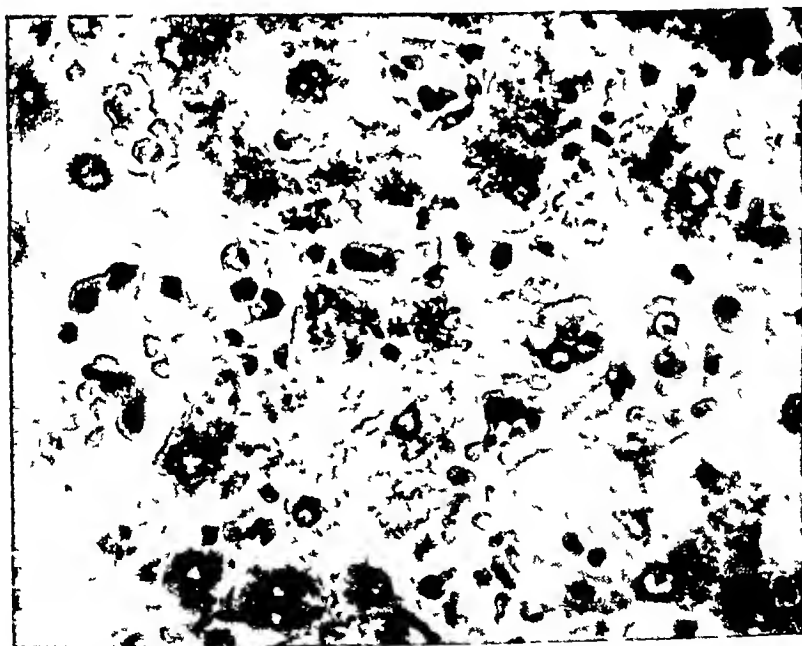


FIG 29

Case 14 Photomicrograph showing plasma cells lying in the liver in sinusoids Magnification  $\times 160$

for a solitary plasmacytoma of the humerus. Shaw (1923) described a case alive and well after curettage and bone graft of the tibia. Rogers (1930) reported a case of plasmacytoma of the femur treated by curettage and radium insertion. The limb was later amputated because of sepsis, and the patient was alive and well three years later. We consider the

treatment of choice to be irradiation using high voltage X-rays through multiple ports, so that a dosage of 3500 to 4000r is delivered to the tumour over a period of four to six weeks. It may be added that the efficacy of any form of treatment for truly solitary bone tumours

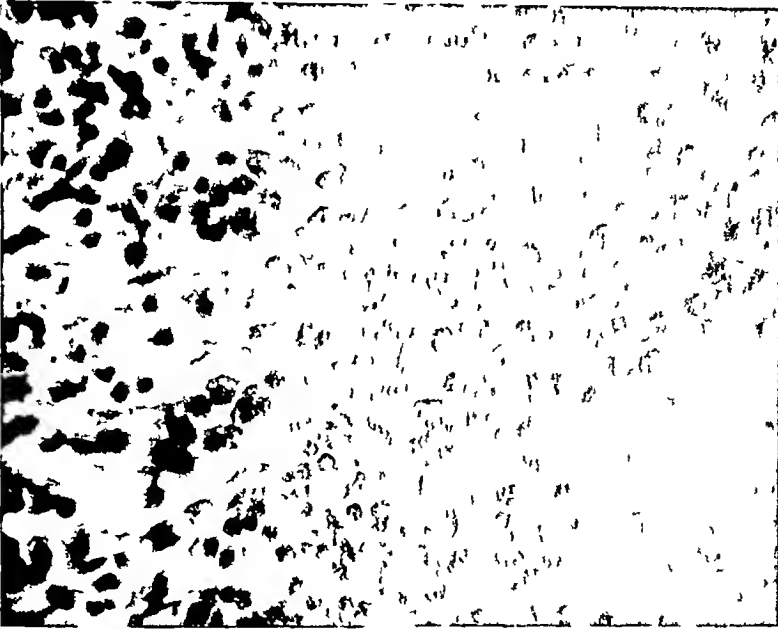


FIG 30

Case 1 Photomicrograph of spleen showing plasma cells lying in sinusoids Magnification  $\times 160$



FIG 31

Case 14 Photomicrograph of lymph node trabeculum showing plasma cells lying in sinusoids Magnification  $\times 160$

must be estimated in the light of the knowledge that most of these tumours seem to be essentially benign. Thus the case reported by Willis (1941), which was discovered only at autopsy, and for which no treatment had been instituted, showed a tumour of a cervical vertebra which probably had been present for at least twenty years. The hope, therefore,

in treating a solitary tumour is that later bone spread such as occurred in case 6 may be prevented, and other complications such as renal blockage (Case 8) may be averted. The general prognosis of solitary bone tumours is good, but the possibility of late onset of multiple tumours (case 6) can obviously affect the expectation of life very seriously.

In our opinion the treatment of choice for soft tissue tumours in the upper air passages excluding the larynx, is a combination of excision with irradiation, because the results of this technique are better than when either method is employed alone. Certain of these tumours, it should be stated, are extremely radiosensitive and success may be achieved with irradiation alone. In the case of tumours of the larynx irradiation without surgery, using teluradium, is to be recommended. A total tumour dose not exceeding 6000r is given over a period of five to six weeks. For cases treated by the combined method a small dose of not more than 3000r on the skin is given pre-operatively through multiple ports either by high voltage X-rays or teluradium. Such a dose temporarily arrests growth and causes shrinking. The tumour remnants are then removed with a diathermy loop, and a post-operative course of irradiation with total dosage of 5000 to 6000r is given over a period of three to four weeks by teluradium. In cases where the antrum and ethmoid air cells are involved and removal is found necessary the cavity should be packed with gauze into the folds of which is placed up to 40 mgm. of radium in numerous foci. These are left in place for two to three days, at the end of two weeks further irradiation is given by intra-oral prosthesis carrying the radium foci. The ultimate prognosis of plasmacytomata in the upper air passages is good as compared with carcinoma or sarcoma. Treatment usually results in temporary arrest of disease although treatable local recurrences are common (Cases 10 and 12). Some show generalised spread to lymph nodes and bones with a fatal result. Case 13 is an example. Hellwig (1943) in reviewing sixty-three tumours from the upper air passages found nine invading lymph nodes and nine more invading bone.

#### RELATIONSHIP OF THE VARIOUS TYPES OF PLASMA CELL TUMOURS

We have now discussed the clinical types and manifestations of plasma cell tumours wherever they occur in the body. Hitherto, some authors have maintained that solitary and multiple plasma tumours of bone represent two separate entities, and Willis (1941) rightly maintained that too few proved solitary tumours have been studied adequately to make any dogmatic pronouncement. However, certain features in the cases of our series are significant. Thus Case 8 was a patient with a proved solitary bone tumour in whom death occurred as the result of a renal condition previously described only as a complication of multiple myelomatosis. In Case 6 a solitary tumour existed for four years, during which time many radiographic examinations of the skeleton were made, and then general spread occurred typical of multiple myelomatosis. With reference to the association of soft tissue and bone tumours, the following facts are of interest. Case 13 demonstrated spread from soft tissues to bone with an interval of two years between the appearance of the tumours. There are also many examples to be found in the literature, the most impressive in view of the long time-lag before bone involvement being Jackson *et al* (1931), Piney and Riach (1931), and Ringertz ninth and fourteenth cases (1938) where intervals of eight and a half years, two and a half years, twelve years, and six years elapsed between the appearance of upper air passage tumours and the discovery of bone spread. Blacklock and Macartney (1932) also agreed that spread to bone can occur. In Case 13 of this series two years elapsed between the appearance of the soft tissue tumour and the paraplegia.

A final word may be said on the general spread which may occur during the terminal phase of all varieties of the disease. Any viscus in the body may be involved, but the liver, spleen, and lymph nodes are most frequently affected. In the liver and spleen, lesions consist of intra-sinusoidal collections of plasma cells, and in the lymph nodes plasma cells are found in the sinuses and inter-follicular tissue, the lymphoid structure remaining intact in all these organs (Cases 1 and 14). Lowenhaupt (1945) suggested that in view of these findings,

together with the bone marrow involvement, and the occasional leukaemic type of distribution, plasma cell tumours present a diffuse reticulo-endothelial proliferation

The generalised nature and spread of the disease provides interesting data for speculation as to the nature of the cells involved in plasma cell tumours. Ewing (1928) said that "multiple myeloma is a specific malignant tumour arising probably from a single cell type". Wallgren (1920) expressed similar views. This hypothesis is attractive when one considers the similarity in cellular appearance between the majority of tumours (Christian 1907, and thirteen of our fifteen cases)

Other workers, whose conclusions are summarised by Ewing (1940), tend to favour multiple varieties arising from the various specific bone-marrow cells (*vide supra* Ewing 1940, page 327). Examples which seem to favour this theory are seen in Cases 4 and 14 of this series.

However, it is clear that no dogmatic statement can yet be made as to the exact origin of the cells in plasma cell tumours, whether from a single cell, either in the bone marrow, or diffusely in the reticulo-endothelial system which in our view is the more likely, or from different specific bone marrow cells, *i.e.*, lymphocyte, granulocyte, and erythrocyte precursors.

We believe that the disease should be regarded as of multifocal origin, as opposed to any theory of spread by metastasis as suggested by Cutler *et al.* (1936), and that it may exist in a wide variety of forms which should not be regarded as distinct diseases, but as gradations in extent and activity of the same disease process.

#### SUMMARY

- 1 Fifteen new cases of plasma cell tumour are reported with a review of the literature
- 2 Case examples are quoted to show the gradual merging of the different clinical and pathological syndromes into one entity
- 3 A comprehensive analysis of the various manifestations of the disease is made
- 4 An attempt is made to correlate the widely differing features of the disease-process and a classification is given
- 5 It is considered that metastasis plays no part in this condition
- 6 The variety of forms of plasma cell tumours are shown as gradations of an essentially similar disease-process, and are not regarded as separate conditions

Our thanks are due to the members of the Honorary Staff of the Westminster Hospital (London) for their permission to make use of case records, to Professor N. F. MacLagan for biochemical reports, to Dr J. G. Humble for haematological reports, to Dr Peter Hansell of the hospital photographic department, to Messrs Ilford & Co for Fig. 16, to Dr Greenblatt of Cape Town, South Africa, for his follow-up report on Case 13, and to Dr Simpson Hall of the Edinburgh Royal Infirmary for the follow-up report on Case 10. More especially our grateful thanks are due to Sir Stanford Cade and Professor R. J. V. Pulvertaft without whose constant help and advice this paper would not have been possible. We wish to acknowledge that part of this work has been carried out with the assistance of a grant from the British Empire Cancer Campaign to the Westminster Hospital.

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# RECURRENT OSTEOCHONDRAL FRACTURE OF THE PATELLA

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Two cases which came under the author's care within three months of one another present interesting points in diagnosis and treatment which are new in relation to a comparatively rare fracture of the patella. The injury is undoubtedly more frequent than would be expected, and many loose bodies removed from the knee joint have originated from such fractures of the patella. It is important that the correct diagnosis should be made early, and that operative treatment should be undertaken promptly, in order to prevent further damage to the joint. The condition is to be suspected when there is haemarthrosis following trauma, and particularly when the patient states that "something slipped in the knee at the time of injury."

The earliest reference to this type of fracture was by Kroner (1905). The patella which had been dislocated laterally, was split in two frontal sections, the articular portion sheared off and remained displaced while the anterior portion reduced itself. Kleinberg (1923) reported the case of a boy, eighteen years of age, with three loose pieces of articular cartilage fractured from the back of the patella by an injury sustained while playing football. He suggested that a fall with the knee in semi-flexion had forced the patella downward against the femoral condyles, shearing off its articular surface. He was unable to find any reference to the fracture. Stewart (1925) reported a frontal fracture not involving the articular surface. He reasoned that the mechanism was a subluxation or dislocation of the patella catching on the lateral femoral condyle or in the intercondylar notch, the pull of the vastus medialis then produced a shearing force which fractured the patella. Krida (1924) also reported a frontal fracture of the patella. Meekison (1937) reported three cases of "a hitherto undescribed fracture of the patella." In each of these a circular piece of the articular surface of the patella, 1.5 to 2 cm in diameter, was torn from its medial-inferior surface and was lying in the lateral pouch. He was unable to demonstrate the fracture by radiographic examination. One of the patients reported pushing the patella back in place, and another stated that he had to "push his knee back in place." The mechanism was thought to be "a glancing blow on the patella from the inner side and directed obliquely posteriorly. The inferior medial corner of the articular surface was knocked out, presumably by the lateral condyle of the femur." Chaklin (1939) briefly reported one case where a defect was present in the cartilage at the lateral border of the patella and a loose body was found in the joint two days after injury. Milgram (1943) reviewed the literature and reported six cases of tangential osteochondral fracture of the patella verified by operation. In three additional cases the diagnosis was strongly suspected but no operation was performed. His well-illustrated article clarifies the mechanism and pathology. Harmon (1945) recently added one case where a loose body was found, originating from the patella, after definite dislocation of the patella.



FIG 1

Case 1 Osteochondral fracture of patella. Radiographs show thin flake of bone but do not disclose its origin.

## MECHANISM OF INJURY

The injury is produced by the patella sliding laterally over the lateral femoral condyle and, in so doing, scoring the articular surface of both patella and condyle. The medial border of the dislocated patella is then caught by the edge of the lateral condyle. When the quadriceps contracts, considerable tangential force is applied, which shears off a portion of the articular cartilage of the patella, usually with a thin layer of underlying bone. In both the cases reported here, direct pressure had also been applied to replace the dislocated patella.

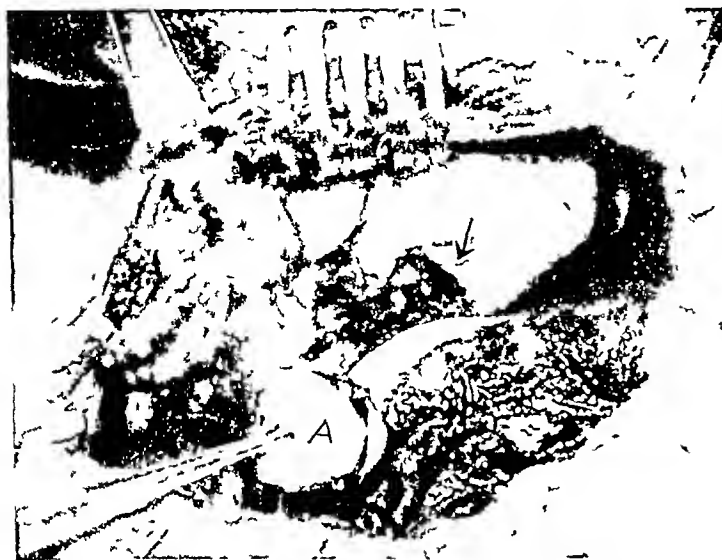


FIG 2



FIG 3

Case 1. Patella exposed through lateral incision (Fig 2). The flake of bone was part of a large osteochondral loose body (A) which has arisen from a defect in the patella (arrow). Exposure of the lateral condyle (Fig 3) shows that an area of articular cartilage has been scraped off by impact of the patella (arrow).

which the loose body could be fitted (Fig 2 shows the defect and the loose body). On the anterior surface of the lateral femoral condyle a thin layer of articular cartilage had been scraped off an area as big as a ten-cent piece (Fig 3). Several small pieces of shredded cartilage were washed from the joint. The margins of the patellar defect were shaved obliquely and shreds of cartilage were removed from the lateral condyle. There was no tearing of the capsule medial to the patella.

Pathological examination by A. J. Blanchard, M.D.—Microscopic examination of the loose body

## Case Reports

Case 1. C. G. P., aged 37 years. Was "strap-hanging" on one of the fast-starting street cars of the Toronto Transportation Commission. He was thrown off balance internally rotating the left femur on the fixed tibia. He felt his patella slip laterally and stick in the displaced position. He applied pressure and it slipped back with a loud crack causing extreme pain. Next morning while bending his knee the patella again slipped over and had to be pushed back. He gave no history of previous dislocations of the patella.

Examination.—The knee joint was full of fluid and movement was limited and painful. There was tenderness over the front of the external condyle. No knock knee deformity was present. Radiographs (Fig 1) showed a loose body lying in the joint. Several views were taken but the origin of the loose body was not discovered. After operation further radiographs showed the defect at the lower border of the patella.

Operation report.—Seventeen days after injury the knee joint was opened through a short incision lateral to the patella. The joint was filled with blood-stained fluid and several clots were expressed. A large piece of articular cartilage measuring 2.5 cm x 1.5 cm x 5 cm was immediately seen in the antero-lateral compartment of the knee. A thin flake of bone was present on one surface. The incision was extended to give better exposure of the joint. A defect was found at the lower medial aspect of the patella into

from the patella shows a large area of hyaline cartilage covered by synovial membrane and a small portion of cancellous bone. The majority of the cartilage cells appear to be still viable but the appearance of the bone cells suggests that they are dead. Beneath the synovial membrane are areas of recent haemorrhage and in these situations there is proliferation of young osteogenic cells and chondroblasts. In the cancellous bone there is evidence of injury with large globules of fat surrounded by foreign body giant cells. There is also a considerable number of foam cells. The impression is gained that this lesion does not represent a true osteochondritis dissecans, but rather that it is the result of an injury with chip-like fracture and incomplete preservation of blood supply.

Convalescence was uneventful. He returned to work as a bank clerk in two months time with a full range of knee movement. He has no complaints eleven months after operation.

**Case 2 B. J. B., aged 35 years.** Admitted to hospital complaining of a painful swollen left knee. Two days previously, while pushing a car out of a snowdrift the car suddenly moved a short distance causing sudden abduction of the knee joint. He gained the impression of something slipping and then "going back" in place. There was severe pain in the knee but he was able to walk on it. Ten months previously, while a prisoner of war in Germany, he had jumped backwards from a fence alighting on his left leg and twisting it outwards as he landed. He had experienced extreme pain so severe that he fainted and when he came to he had thought that the knee was dislocated because it seemed to project on the inner side. He had struck the inner side of the knee with his hand and heard a loud click accompanied by extreme pain. The knee had become swollen but he carried on. After this he had occasional aching over the inner side of the knee, but no locking or giving way.

*Examination of left knee*—There was a large effusion. Coarse crepitus could be felt when the patella was moved on the femur. A loose body was palpated above and to the outer side of the patella. There was no ligamentous instability. There was tenderness along the medial border of the patella and over the joint line medially. Radiographs (Fig 4) showed a loose body in the outer part of the suprapatellar region and irregularity at the inner distal border of the patella.

*Operation note*—Under spinal anaesthesia an incision was made medial to the patella four inches in length. The joint was full of blood-stained fluid. A fibro cartilaginous loose body about as big as a ten-cent piece immediately presented. The articular surface of the lower medial quadrant of the patella was roughened and a segment was missing. There had been an attempt at repair of this segment with fibro cartilaginous tissue. The loose body had obviously arisen from the centre of this area. Over the front of the external condyle there was an area from which the thin outer layer of the articular cartilage had been scraped. (The patella could be readily dislocated laterally.) In the outer wall of the suprapatellar pouch a loose body was embedded. It was shelled out and found to be composed of cartilage and bone. It was approximately the size of the defect in the patella. The patella was removed by subaponeurotic dissection. The synovial membrane was closed behind the defect left by the removal of the patella and the quadriceps tendon was sutured to the patellar tendon with a strip of fascia taken from the thigh. The suture line was reinforced with three No. 3 chromic cat-gut sutures. The synovial membrane was then closed medial to the patella and the capsule of the joint overlapped half an inch. Dermal sutures were used in the skin and a plaster-of-Paris cast applied to the leg.

*Pathological report by A. J. Blanchard, M.D.*—The specimen consists of a patella and two loose bodies (Fig 5) from the knee joint. The medial half of the patella shows an eroded area measuring 2.5 × 2 cm. At the margins of this area there is an obvious tear in the surface cartilage, and beneath this there is recent blood clot. Medial to this point there is an irregular area which appears to represent a healed fracture. The two loose bodies measure respectively 1.5 × 1.5 × .5 cm and 2 × 1.5 × .5 cm. The former of these shows a layer of fibrous tissue on one surface and smooth glistening opposing surface. The second piece shows what appears to be bone on one surface and cartilage on the other.

Microscopic examination of a section through the old eroded area of the patella shows loss of the surface hyaline cartilage and in this area the bone is covered by fairly dense fibrous connective tissue containing an increased number of capillary blood vessels. Section through the recently injured area reveals a recent tear in the surface cartilage with masses of blood clot. There appears to be no under-



FIG 4

Case 2 Old and recent osteochondral fractures of the patella. There is a loose body in the outer suprapatellar region and irregularity of the inner border of the patella.

lying pathological condition in the patella. Section through the larger loose body shows hyaline cartilage undergoing resorption. There is proliferation of connective tissue and osteoclasts are present. Section of the other loose body shows mostly hyaline cartilage and masses of quite dense fibrous tissue. A few spicules of dead bone are present.

Convalescence was prolonged by thrombophlebitis which developed three weeks after operation. Mobilisation of the knee joint and muscle re-development was consequently delayed. Eight months after operation his only complaint was of some aching in the knee after sitting. He still had one inch wasting of the thigh with knee movement from 180 to 70 degrees.

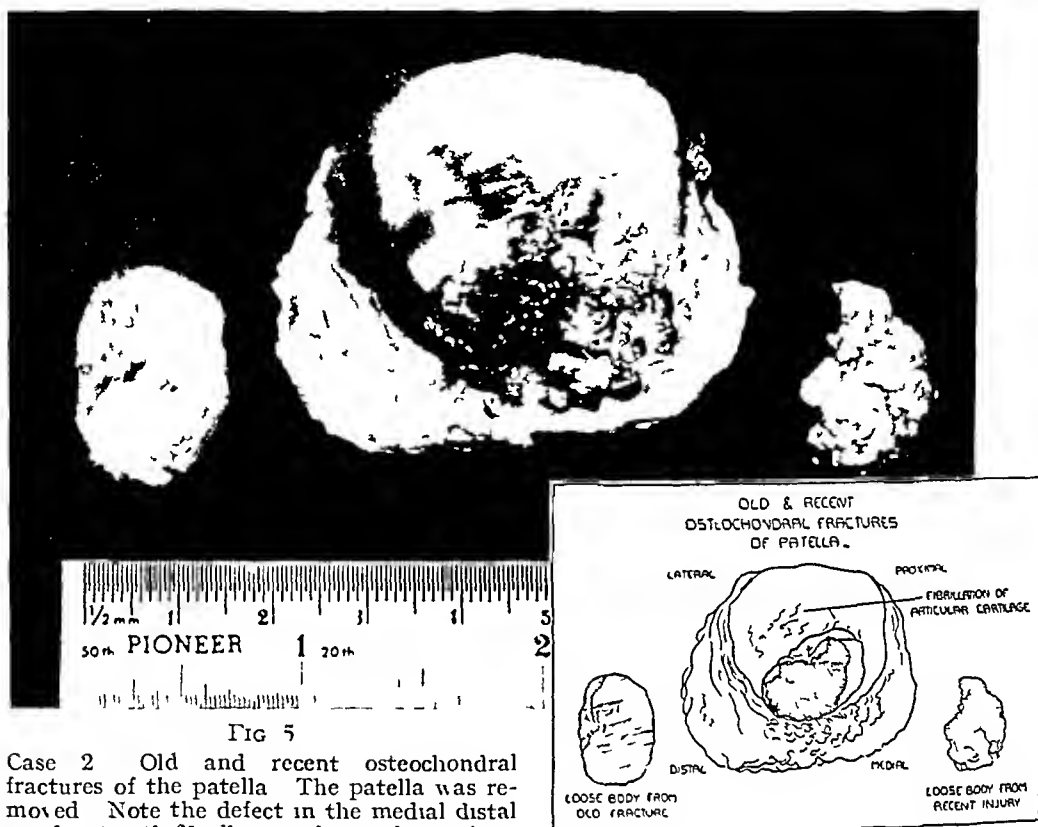


FIG 5

Case 2 Old and recent osteochondral fractures of the patella. The patella was removed. Note the defect in the medial distal quadrant with fibrillation of articular surface and two loose bodies one from the old fracture and one from the recent injury.

### DISCUSSION

The history of both these cases, and the operative findings, leave no doubt as to the mechanism of injury. Most reported cases have been children or adolescents, but these two were adult males with no knock-knee deformity. The defects in the patella could be demonstrated radiographically but lateral, oblique, and "sky-line" views were necessary to catch the right projection. A pneumo-arthrogram was tried in Case 2, but it did not make the defect any more clear, it would, however, be of value in revealing a defect which involved only the articular cartilage of the patella. Of particular interest in both cases was the history of recurrent injury. In the first case the two injuries were on succeeding days, two and a half weeks before operation. In the second case there was an interval of ten months between the two injuries, the second injury occurring one week before operation. The finding in this knee joint of two loose bodies, and the evidence of recent and old damage to the medial surface of the patella, confirmed the history. This was, in effect, a case of recurrent osteochondral fracture of the patella. The second injury scraped off part of the fibro-cartilage which had partly repaired the original defect in the patella (Fig 5). The possibility of recurrence of this injury has not previously been recorded, and it is an important consideration in determining treatment. In Case 2 the joint was approached through a median patellar incision and in the course of closing the wound the capsule was overlapped. Plication of the

capsule should be sufficient to prevent recurrent injury in cases without knock-knee deformity such as may be found in recurrent dislocation of the patella. The patella was removed in Case 2 because extensive involvement of the articular surface had been causing symptoms since the original injury, and would undoubtedly have led to patello-femoral arthritis.

**Later note** Since submission of this article the author has treated three additional cases of osteochondral fracture of the patella. Two were confirmed by operation. In each there was a typical history of dislocation of the patella with large effusion into the joint.

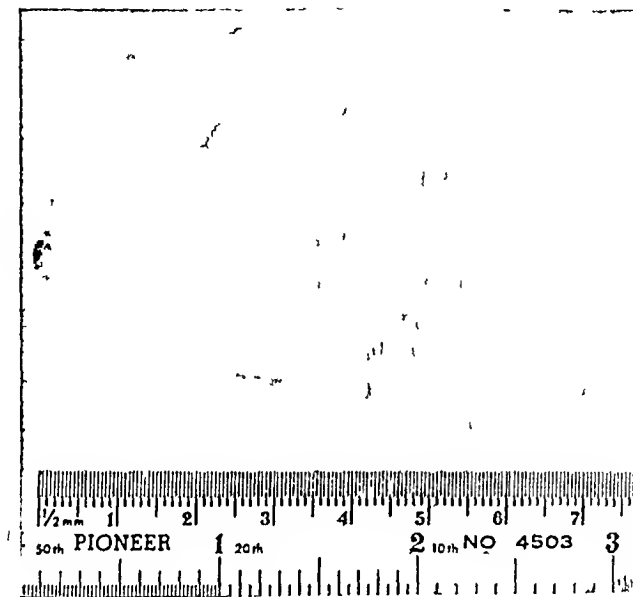


FIG 6

Osteochondral fracture due to dislocation of the patella. The detached fragment of articular cartilage had a pedicle of synovial membrane.

Both had previously been diagnosed as tears of the medial meniscus. Fig 6 shows the detached fragment of articular cartilage of the patella in Case 3, there was a pedicle of synovial membrane. Operation in Case 4 showed scoring of the articular surface of the patella and lateral femoral condyle with a small area of cartilage scraped off the condyle. The fifth case showed characteristic radiographic findings with a defect on the posterior-medial border of the patella.

### CONCLUSIONS

Osteochondral fractures of the patella should be recognised early, loose bodies removed, and defects in the articular surfaces smoothed off, or the patella removed if it is extensively involved. Plication of the capsule on the medial side is recommended in order to prevent recurrence of the injury and to prevent dislocation of the quadriceps tendon in cases where the patella is removed.

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# EXCISION OF PATELLA FOR RECURRENT DISLOCATION

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Removal of the patella has been recommended for recurrent dislocation, but it has not been emphasised that this operation has distinct advantages over "realignment" procedures. I now regard removal of the patella as essential. Unsuccessful results have been reported for the reason that the regenerated patella, or the fibrous tissue in which it forms, has continued to slip over the femoral condyle. This has not occurred in any of my patients. When suturing the capsule and ligaments after removal of the bone, I take care to direct the pull of the strong outer portion of the quadriceps tendon to the inner side of the ligamentum patellae, and it may well be that it is this precaution which prevents recurrent displacement.

Most surgeons have seen osteo-arthritis (sometimes with recurrence of dislocation) arising some years after realignment operations. This has usually been attributed to friction between the patella and femur because the patella runs in a new line, so that chondritis develops. From my observation of patellae removed—one even at the early age of eight years—I believe that retropatellar chondritis is due to the recurrent dislocation, that it is present before any operation is done, and that it progresses inevitably to osteo-arthritis. It follows that any primary operation other than patellectomy must give rise to late osteo-arthritis.

I first performed patellectomy for this condition a little over three years ago. Having embarked upon a realignment operation, with swinging of a tongue of capsule from the inner to the outer side, it occurred to me that the recurrent displacement must cause damage to the slipping bone, and inspection did in fact reveal that the articular cartilage over the outer half, and on the vertical ridge, was deeply fragmented and pitted. Several small particles had separated and were floating free in the synovial fluid. The articular cartilage of part of the external femoral condyle was similarly fragmented over an area the size of a penny, and a central area the size of a halfpenny was completely denuded of cartilage, with bare bone exposed. The site of this cartilaginous injury was in the front of the external condyle, one and a half inches below the upper limit of the articular surface and near the angle of the condyle—just where the patella jumps over when dislocating. The patella was removed, and on closer examination the damage was so apparent and impressive that in all subsequent cases of truly recurrent dislocation I have removed the bone. Similar cartilaginous damage to the patella, and sometimes to the femur, has now been seen in six consecutive cases. The injury to the patella is not always confined to the middle and outer sides. Sometimes it has extended to both sides, but the central area is always most affected. Sometimes there is a band of thickened, soft, and oedematous cartilage forming a horizontal ridge which is much more apparent than the normal vertical ridge. Recovery has always been uneventful. Ultimate function has approximated no less closely to the normal than is usual after a good patellectomy. In no case has there been recurrent slipping of the tissue which forms in place of the patella. A typical case illustrates the findings (Figs 1-2).

**Miss P. H., aged 17 years.** In February 1944 this girl, who was a good witness, complained that one or other knee gave way intermittently, with pain and displacement of the knee cap. She reported that on two occasions the dislocation had been reduced under anaesthesia by her doctor. At the time that I saw her the left knee was giving most trouble. Both patellae were of the type that one is accustomed to associate with recurrent dislocation. On February 23, 1944, patellectomy was carried out on the left side. The bone was shelled out of the capsule and tendons through a vertical approach. The posterior surface was fragmented, a small patch of the femoral condyle was also fragmented but there was no actual erosion. She was walking within fourteen days and in eleven weeks had regained a full range of movement with almost complete control.

In February 1947 she complained that the right knee had never ceased to give trouble—dislocation was becoming more frequent and she wished to have the same operation performed on this knee. The left knee had given no trouble since the operation—she regarded it as normal and clinical examination showed normal function. On March 19 1947 the right patella was removed. The usual changes were found in its articular surface. There was no erosion or fragmentation of the femoral articular cartilage but at the spot usually affected a small mesh of fine vessels had grown about half an inch into the cartilage from the articular margin.

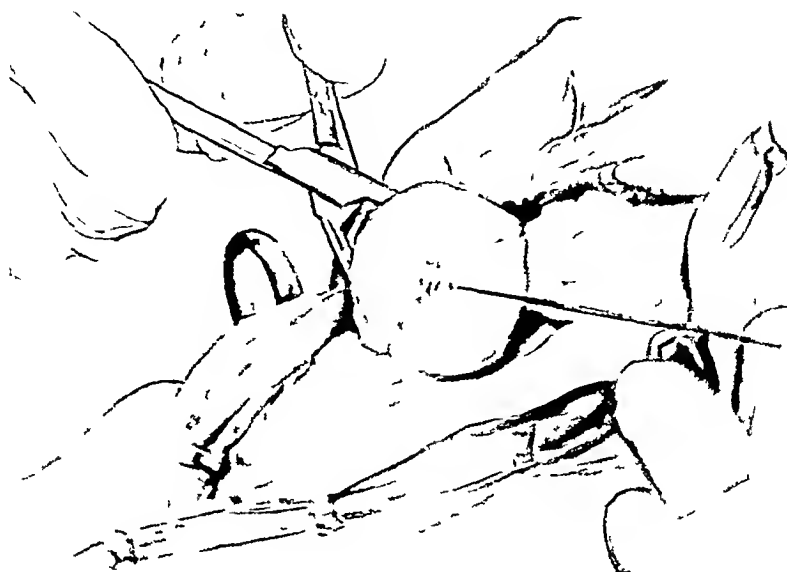


FIG 1

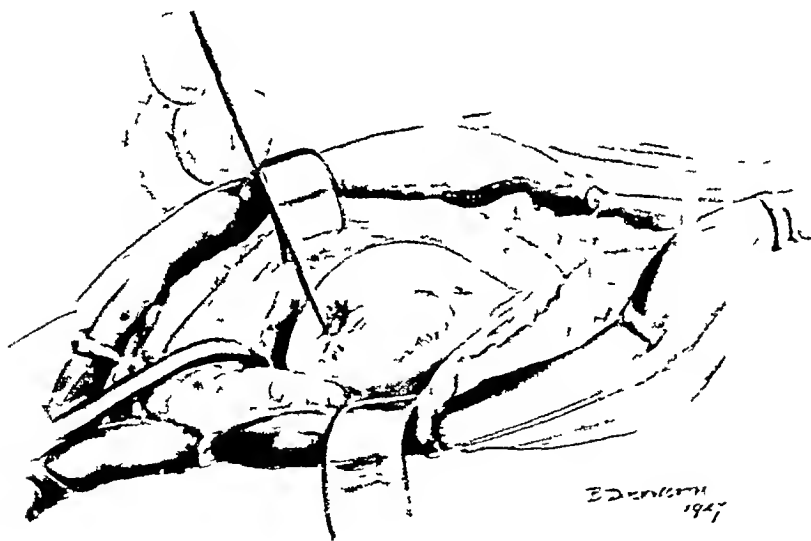


FIG 2

Taken from colour photograph at operation. Fig 1 shows the patella reversed and partly extracted. Note the horizontal yellow-coloured oedematous ridge and the fragmentation of the articular cartilage in which a probe has been inserted. Fig 2 shows the femoral condyle. Note the fragmentation and erosion of the condyle of the femur at the point indicated by a probe.

**Summary**—Patellectomy is at present the best operation for recurrent dislocation, not only because the immediate result is excellent, but because it avoids the later arthritis which must inevitably arise if a patella so damaged is retained.





FIG 1



FIG 2

Case 1 Short femur and congenital coxa vara The early stage of the short femur is seen in Fig 1 A still earlier radiograph was published in a previous report (Golding 1938) but it was a glass plate and is no longer available Seven years later there is typical congenital coxa vara (Fig 2)

# CONGENITAL COXA VARA

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In a previous communication it was suggested that congenital coxa vara and the short femur of micromelia were variations of the same congenital anomaly (Campbell Golding, 1938). Eleven patients were then reported, one of whom had been followed over a period of thirteen years. Two other cases have been seen recently and are included in this report (Figs 3-6).

It is known that the upper shaft of the congenitally short femur, which appears to be absent, is actually formed in cartilage though imperfectly. The radiographic appearances in later life depend upon the extent to which this cartilage is converted to bone—a process which is often incomplete in the femoral neck and sometimes in the subtrochanteric region.



FIG 3

The short femur



FIG 4

The intermediate stage



FIG 5

Congenital coxa vara

Case 2 Short femur and congenital coxa vara in three stages of development

In early months radiographs show only the lower shaft of the femur, there is no evidence of the upper shaft, neck, or upper femoral epiphysis. The upper femoral shaft then ossifies (Fig 3) but it is not until some time later that the upper femoral epiphysis appears, leaving a broad band of cartilage in the region of the epiphyseal line (Fig 4). The development of separate areas of ossification within this zone of cartilage gives an appearance of "fragmentation" which has sometimes been mistaken for osteochondritis, and for the appearance of "triangular fragments," often described in the lower part and sometimes in



FIG 6

Female child born with short right leg When first seen at the Robert Jones and Agnes Hunt Orthopaedic Hospital at the age of seven years there was five inches of shortening radiographs showed congenital coxa vara (Fig 6) The cervical deformity was corrected by subtrochanteric osteotomy thereafter the neck of the femur ossified firmly By the time the child was aged nine years there was seven inches of shortening (right femur eight inches, left femur fifteen inches right tibia twelve inches left tibia twelve inches) The limb was disarticulated through the knee joint the patella excised and the medial femoral condyle flattened The child is now aged eleven years and walks well in a light metal above-knee artificial limb (Sir R Watson-Jones case)

the upper part of the femoral neck, which is of no particular importance (Fig 5) Final ossification of this region is very delayed weight-bearing meanwhile causing deformity or even complete solution of continuity A second area of imperfect and delayed ossification may also be found below the trochanters where the shaft is frequently thin, sometimes dense, and the differentiation of medulla and cortex imperfect (Figs 1-2) Weight-bearing may cause deformity or solution of continuity at this level

The final results of attempting to walk on the defective support of imperfectly ossified areas of cartilage are varus deformity of the neck, varus deformity of the subtrochanteric region of the shaft, beaking of the greater trochanter by muscle tension on cartilage and soft bone, and usually increased shortening of the limb The appearances are very variable because the condition develops slowly over many years, in some cases the deformity is bizarre, but all the features may be explained by the theory that congenital coxa vara is the final form of the congenitally short femur

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## OSTEOGENESIS IMPERFECTA

and

## Osteogenesis Imperfecta Cystica

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Osteogenesis imperfecta (synonyms fragilitas ossium, idiopathic osteopsathyrosis, periosteal dysplasia) is characterised by fragility of skeletal bones. The cause is unknown. Cases may be grouped as pre-natal and post-natal, but there is no clear-cut distinction between the two groups except in the date of the first fracture which depends upon the severity of the disorder. Pre-natal cases are on the average decidedly more severe, many die at birth or survive only a few days or weeks. The exact proportion of surviving to fatal cases is unknown. A child may sometimes survive several months despite birth fractures of many ribs. Osteogenesis imperfecta tarda is the term often applied when there is delay in occurrence of the first fracture, for example, a girl with intensely blue sclerotics sustained the first of many fractures at the age of seven.

*Hereditary and familial influences* are apparent in a minority of both groups, but more often in the post-natal group. The disorder may be inherited through either parent. Many family trees have been published, some covering four generations, with certain members marked as having blue sclerotics, some also with bone fragility, but others without (50 per cent, Fraser, 1934).

*Sex*—Both sexes are affected, females more frequently than males, of thirty-five cases known to the writer nineteen were females.

*Blue sclerotics*, fairly deep indigo and not just blue as may often be seen in normal babies, may be present in both groups of cases but more frequently in the post-natal group. The depth of colour sometimes fades with age.

*Otosclerosis* may occur in those who live till the third decade, but deafness has twice been reported as early as the thirteenth year (Cleminson, 1926, and Bigler, 1923). Bickel *et al* (1943), analysing a series of forty patients found deafness in 45.5 per cent of the hereditary and only in 17.3 per cent of the non-hereditary cases. Of adults with blue sclerotics 60 per cent are said to develop otosclerosis with or without evidence of bone fragility (Rodger, 1936). Osseous fragility, blue sclerotics, and deafness constitute Van der Hoeve's syndrome. *Laxity of joints* with susceptibility to strain and dislocation is not uncommon in families afflicted with one or more elements of the syndrome.

*Osteomalacia*—An osteomalacic element (mollities), *i.e.*, softening leading to bending, may be present in addition to fragility of bone and this contributes to the development of deformities, particularly in pre-natal cases. This feature is strikingly displayed in the pelvis which is indented and tri-radiate in 25 per cent of all patients.

*Fractures*—The number of fractures varies enormously. In severe cases fractures are spontaneous and cause little if any pain. A newly born child may exhibit as many as 100 fractures, many involving the ribs. One patient with rather less severe manifestation of the disorder, but nevertheless of the pre-natal type and with blue sclerotics, died at the age of eight having sustained ninety-eight fractures. One bone is often fractured repeatedly, for example, a child sustained twenty-three fractures of only three bones. Refracture may of course be favoured by the additional osteoporosis which results from immobilisation of the first fracture, or by persistent angulation of the fragments, or by both these factors.

*Dwarfing*—Most severe cases are dwarfed. Dwarfing is accentuated, or indeed largely accounted for, by deformities of the limbs and curvature of the spine. Scoliosis is often severe and is present in at least a quarter of the cases. In pre-natal cases the limbs may be relatively short, sometimes to a striking degree.

*Skull*—The typical skull is broad, with prominent parietal and occipital bones (*crâne à rebord*), the ears are directed downwards as well as outwards. In some familial and hereditary cases the skull has prominent frontal and occipital regions with no bulge or ridge in the temporal region.

*Teeth*—The milk teeth are poorly calcified and semi-translucent or waxy. The permanent teeth are better calcified, even in post-natal cases, and they are usually normal in appearance.

*Intelligence* is at least up to the average.

*The musculature* is extremely feeble in all but milder cases, this hypotonicity being no doubt secondary to fractures and deformities.

*Blood chemistry* varies but is usually within normal limits, and is of no diagnostic value.

**Clinical progress**—A tendency towards improvement is often evident. This is seen most frequently in mild pre-natal and in post-natal cases. A few patients, in spite of severity of the disorder survive for many years, for example, a boy, a pre-natal case, was alive at the age of nineteen though bedridden since birth. Another pre-natal case, only slightly less severe and markedly dwarfed is still able to earn her living as a secretary at the age of twenty-nine.

**Pathology**—The essential pathology is imperfect formation and imperfect calcification of bone trabeculae. Islands of cartilage are seen, notably under the periosteum, with chondroid or incompletely calcified osteoid trabeculae taking the place of properly calcified bone. The periosteum is thickened, and there is failure to form a normal shell of cortical bone beneath it. The bone is discontinuous and fragmentary. The medullary contents may be in part fibroid, lymphoid, or fatty. Deficiency in numbers of osteoblasts has been stressed as an essential factor (Knaggs, 1924), but histological study of nine cases has shown great variation. In some, the number of osteoblasts was quite numerous although the formation of bone was deficient.

**Radiographic appearances**—Three groups of cases may be defined.

*Type 1—Thick bone type* (Fairbank, 1930)—These are severe pre-natal cases, born with limbs which are stunted as in achondroplasia and with numerous fractures, notably in the ribs. The major long bones are short, they are usually broad and thick, and show one or more fractures with ample callus. The proximal segments of the limbs, the femora and humeri, are most severely affected, but the tibiae may also be enlarged. The appearance of the bones suggests that the thickening is not due entirely to callus formation following recent or remote fractures. It may be seen up to three months after birth but is seldom met with later. Other bones show general osteoporosis and are similar to those seen in Type 2.

*Type 2—Slender, fragile bone type*—This condition is seen in pre-natal cases which survive more than a few months, and in all post-natal cases. The skeleton as a whole is osteoporotic and the long bones are usually slender. The cortex is characteristically thin and of deficient density. The extremities of the bone often appear large, and in older children they may show varying degrees of honeycombing. Occasionally the shafts of some long bones, perhaps after repeated fracture, may be slender and yet surprisingly dense as compared with the ends of the bones. Deformities due to fracture or bending are common. Transverse lines of dense bone, straight or wavy, often mark the ends of the metaphyses. In one ante-natal case, at the age of fourteen years, many rings of dense bone were seen in the epiphyseal lines in the region of the knee joint. The fibulae may be reduced to little more than faint lines. The skull is thin and Wormian bones may be present. The pituitary fossa is normal. The petrous bone may show excessive density. The vertebral bodies are translucent, shallow, spread, and biconcave, the intervertebral discs being biconvex.

*Type 3—Osteogenesis imperfecta cystica*—This name was suggested in 1935 for cases with pronounced honeycombing of bones. It is extremely rare. Only two living patients and one post-mortem skeleton are included in this series. The condition dates from birth. It is definitely progressive. Cystic changes which are more pronounced in the lower than in the

upper limbs become increasingly evident with advancing years. During the first few years of life the upper limbs may show no more than simple osteoporosis. Deformity due to fracture and bending of bone is progressive. Hereditary and familial influences are not in evidence. In the two cases here recorded the sclerotics were not blue. The condition differs from multiple diffuse fibrosis of bone in that bone change occurs much earlier, the radiographic appearances are not really similar and the histological appearances are quite different.

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The writer is greatly indebted to his many friends who have supplied him with clinical details of cases under their care. Figs 1, 5, 6 and 24 are reproduced by courtesy of the *British Journal of Surgery*.

### CASE 1—OSTEOGENESIS IMPERFECTA—Thick Bone Type—Pre-natal

(Figs 1-4) Male. Lived three days. Third child—others healthy. No history of bone fragility in family. Ossification of skull very imperfect and patchy. Very large fontanelle. Bossing of parietal bones. Numerous fractures including most of the ribs (under Dr G F Still).

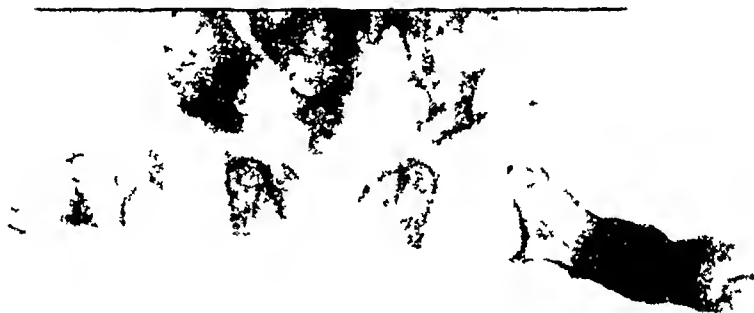


FIG 1

Case 1. Greatly thickened cylindrical femora with multiple fractures, the thickening is not entirely due to callus. Upper ends of tibiae somewhat enlarged.



FIG 2

Case 1 Note that there are fractures of all long bones including the clavicles which show some relative thickening also fractures of most of the ribs



FIG 3

Case 1 Note the relative shortness of limbs suggesting achondroplasia

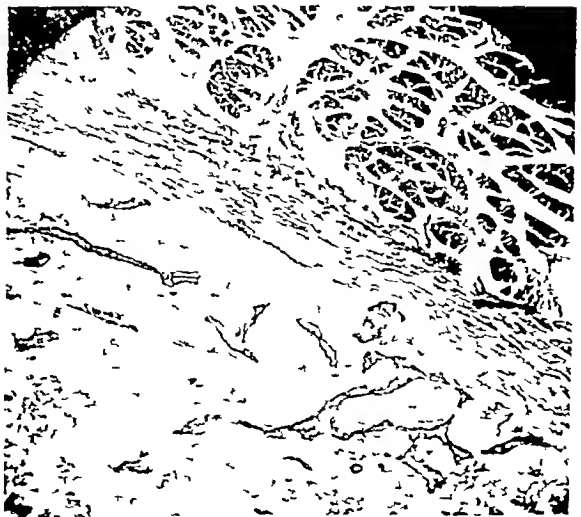


FIG 4

Case 1 Section of femoral shaft fragmentary bone formation complete absence of continuous cortical layer beneath thickened periosteum in this case marked deficiency of osteoblasts



**CASE 2—OSTEOGENESIS IMPERFECTA—Thick Bone Type—Pre-natal**

(Figs 5-6) Female Lived ten weeks Seventh child Mother very poorly nourished during pregnancy Other children healthy Skull very imperfectly ossified Serum calcium low—5.45 mg per cent (Under Dr F J Poynton)



FIG 5

Case 2 Note the short thickened humerus with fracture and callus formation The radius and ulna are not generally thickened but are poorly calcified with thin translucent cortices and somewhat bulbous extremities

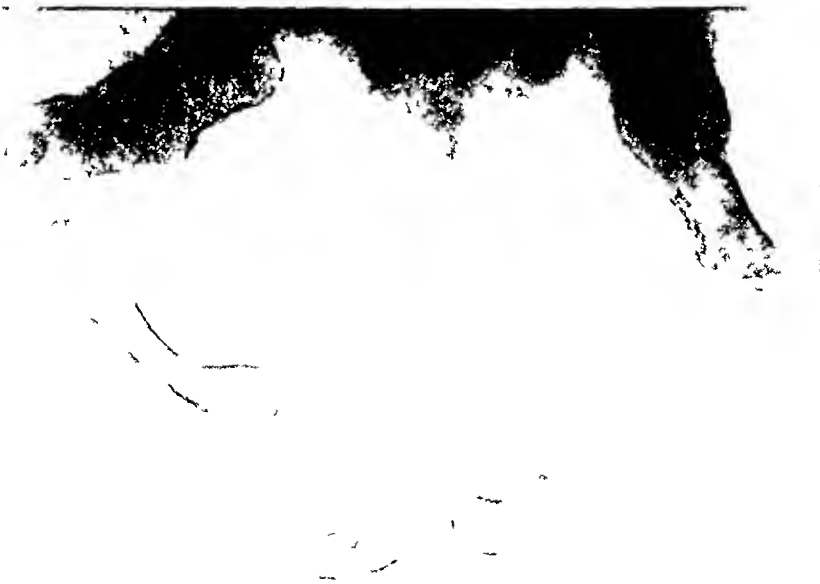


FIG 6

Case 2 The tibiae as well as the femora are affected by the general thickening which is apparently not due to callus

## CASE 3—OSTEOGENESIS IMPERFECTA—Slender Bone Type

(Figs 7-8) Girl aged six years History imperfect but almost certainly pre-natal in origin Only child Dwarfed Has had many fractures Sclerotics blue, but not markedly so

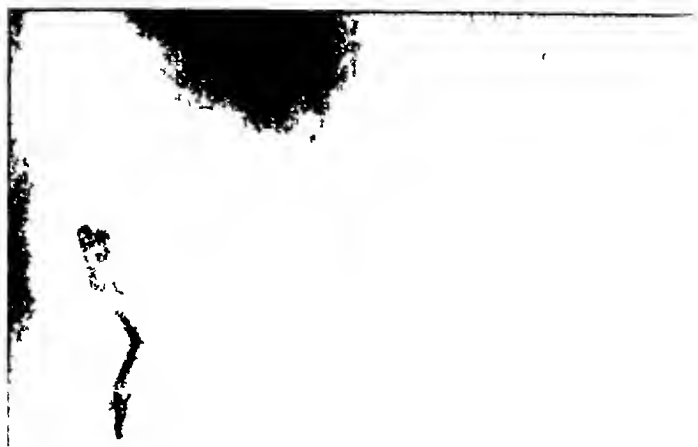


FIG 7

Case 3 Femora show very slender shafts with much deformity due mostly to malunion of fractures Typical osteoporosis of the ends of the bones and the epiphyses Pelvis slightly deformed

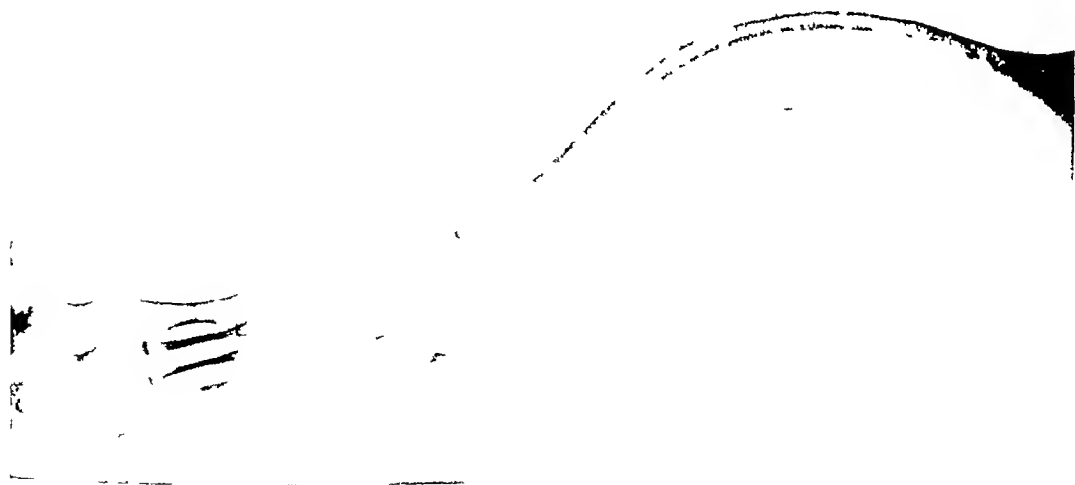


FIG 8

Case 3 Typical slender imperfectly ossified tibia and fibula with marked deformity apparently due more to bending (mollities) than to fractures Bones of foot show similar fragile appearance Note the poor cortex of tarsal bones which do not show the pencilled outline seen when translucency is due to simple atrophy

**CASE 4—OSTEOGENESIS IMPERFECTA—Ante-natal (Brother of Case 5)**

(Figs 9-10) First fracture at six months, though disease certainly ante-natal. Severe case. Has never walked though aged eleven years when last seen. Sclerotics not noticeably blue. Elder sister also affected (Case 5) but a brother and sister, the first and third children of the family, are normal. No known hereditary influence. Died when aged nineteen years.

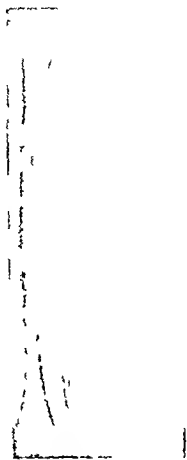


FIG 9

Case 4 Tibia when aged 5 years (Fig 9) shows extremely slender fragile bones with one fracture. When aged 8½ years (Fig 10) extremities of femur show typically poor ossification. Central portion of shaft slender but sclerosed. Ununited fracture with persistent tendency to angulation.



FIG 10

**CASE 5—OSTEOGENESIS IMPERFECTA—Ante-natal (Sister of Case 4)**

FIG 11

Case 5 at 12 years of age. Slender femora with coxa vara. Tri-radiate pelvis and scoliosis. Shaft of left femur fractured.

## CASE 5--OSTEOGENESIS IMPERFECTA--Ante-natal (Sister of Case 4)

(Figs 11-13) Born with fractured humerus. First seen at age twelve years. Sclerotics not blue. Has shown some tendency towards improvement. Angular deformity of right tibia and left femur resulted in very delayed union of fractures of these bones with a strong tendency to refracture. Was able to walk with appliances for various periods between fractures. Dwarfed—not entirely by fractures. Severe scoliosis. Tri-radiate pelvis—bones are therefore soft as well as fragile. At age twenty-nine years is able to walk, and work as a secretary.



FIG 12

Case 5 at 16 years of age. Note the slenderness of right femur and marked shortening of left femur due mostly to anterior bowing.



FIG 13

Case 5 at 19 years of age. Left femur shows gross anterior bowing the result of repeated fractures not completely united after many months.

**CASE 6—OSTEOGENESIS IMPERFECTA**

**Ante-natal** (Fig 14) Male aged seven-teen years Born with one leg fractured History of at least seventeen fractures Sclerotics markedly blue Half-sister (same mother), has blue sclerotics but no fragility Tri-radiate pelvis Scoliosis

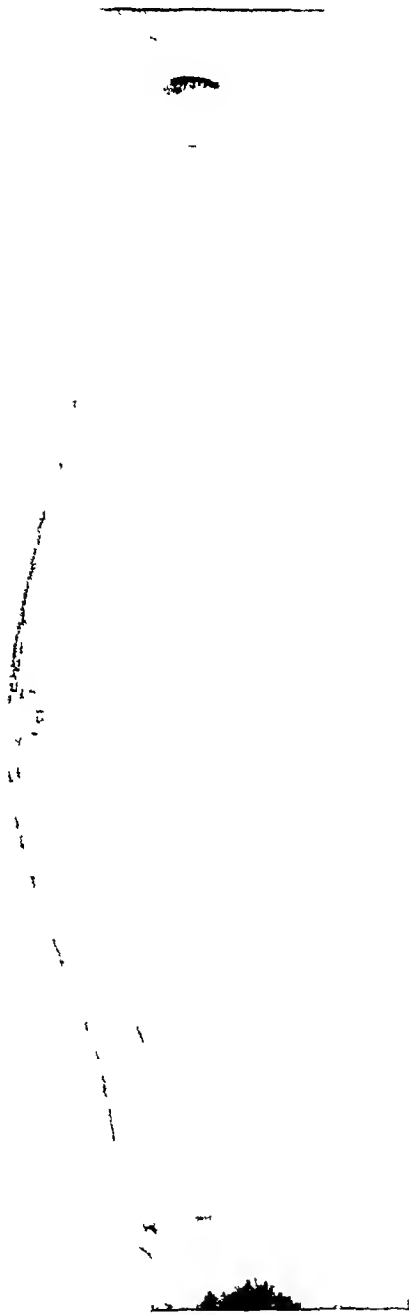


FIG 14

Case 6 Note the unusual general cancellous appearance with poorly defined cortex and general osteoporosis The deformity suggests bending of the bones rather than malunion of fractures, but the leg has been fractured at least once

**CASE 7—OSTEOGENESIS IMPERFECTA**

**Post-natal** (Fig 15) One of twin girls aged seven years Both were affected and both showed blue sclerotics The onset was post-natal There were familial and hereditary factors A comparatively mild case



FIG 15

Case 7 This leg has been fractured nine times the last 2 year ago Shows typical slender fragile type of bones with imperfectly united fractures very easily refractured Child was walking Deformity corrected by open operation

## CASE 8—OSTEOGENESIS IMPERFECTA—Ante-natal

(Figs 16-17) Female baby aged nine months Born two months prematurely with a leg broken The head was markedly flattened antero-posteriorly A very severe case with multiple fractures of nearly all ribs, both thighs, both legs, both arms, and both forearms, and with gross deformities of the limbs

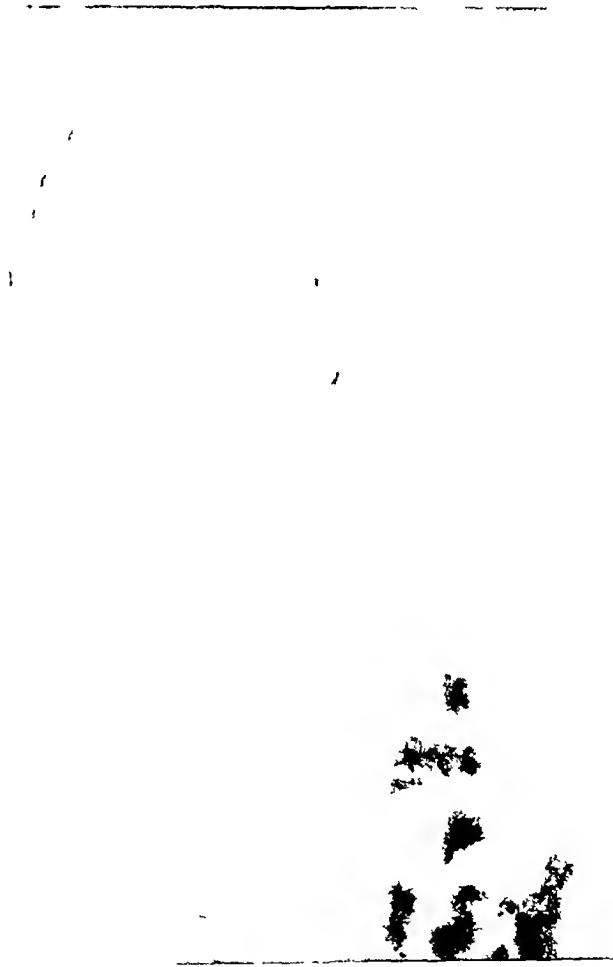


FIG 16

Case 8 Note that nearly all the ribs are fractured some are broken in two or three places Nevertheless the child was alive nine months after birth The upper limb is typical of the condition with multiple fractures and gross deformity



FIG 17

Case 8 Severe ante-natal case (aged nine months) with multiple fractures of many ribs (Fig 16) and of all four limbs (Fig 17) Exceptionally marked fragility with gross deformity of all long bones of the lower limbs

**CASE 9—OSTEOGENESIS IMPERFECTA—Mild Post-natal Case**

(Fig 18) Male aged seven years The patient's father broke his leg three times between the ages of fourteen and sixteen, but has not blue sclerotics No other fractures in family The child's sclerotics are rather blue Only three fractures to date



FIG 18

Case 9 Spine shows osteoporosis with very shallow biconcave vertebral bodies and deep biconvex discs



## CASE 10—OSTEOGENESIS IMPERFECTA

(Figs 19-22) Male aged nine years Very numerous fractures dating from birth Scoliosis and tri-radiate pelvis Circumference of head twenty-two and a half inches—of abdomen twenty-three inches Has never walked Sclerotics not blue When sitting, height was seventeen inches Blood chemistry shows no striking abnormality Was still alive at the age of nineteen years (Under Mr H Tyrrell-Gray)



FIG 19

Case 10 Note the absence of cortex and the suggestion of honeycombing of the bones



FIG 20

Case 10 The bones are grossly deformed and there is almost complete absence of cortex



FIG 21

Case 10 Radiographs of lower limbs show gross deformity with irregular density both the result—at least in part—of multiple fractures



FIG 22

Case 10 Male aged 9 years with very numerous fractures dating from birth. Note the characteristic bulge in the temporal regions. The circumference of the head was twenty-two and a half inches, the circumference of the abdomen twenty-three inches, the sitting height seventeen inches. Calcification of the teeth is not bad.

## CASE 11—OSTEOGENESIS IMPERFECTA

(Fig 23) Girl aged fourteen years. Pre-natal onset. No hereditary or familial influence. Temporary teeth were markedly translucent. Sclerotics not blue. Many fractures had been sustained—fourteen in the first three years of life.

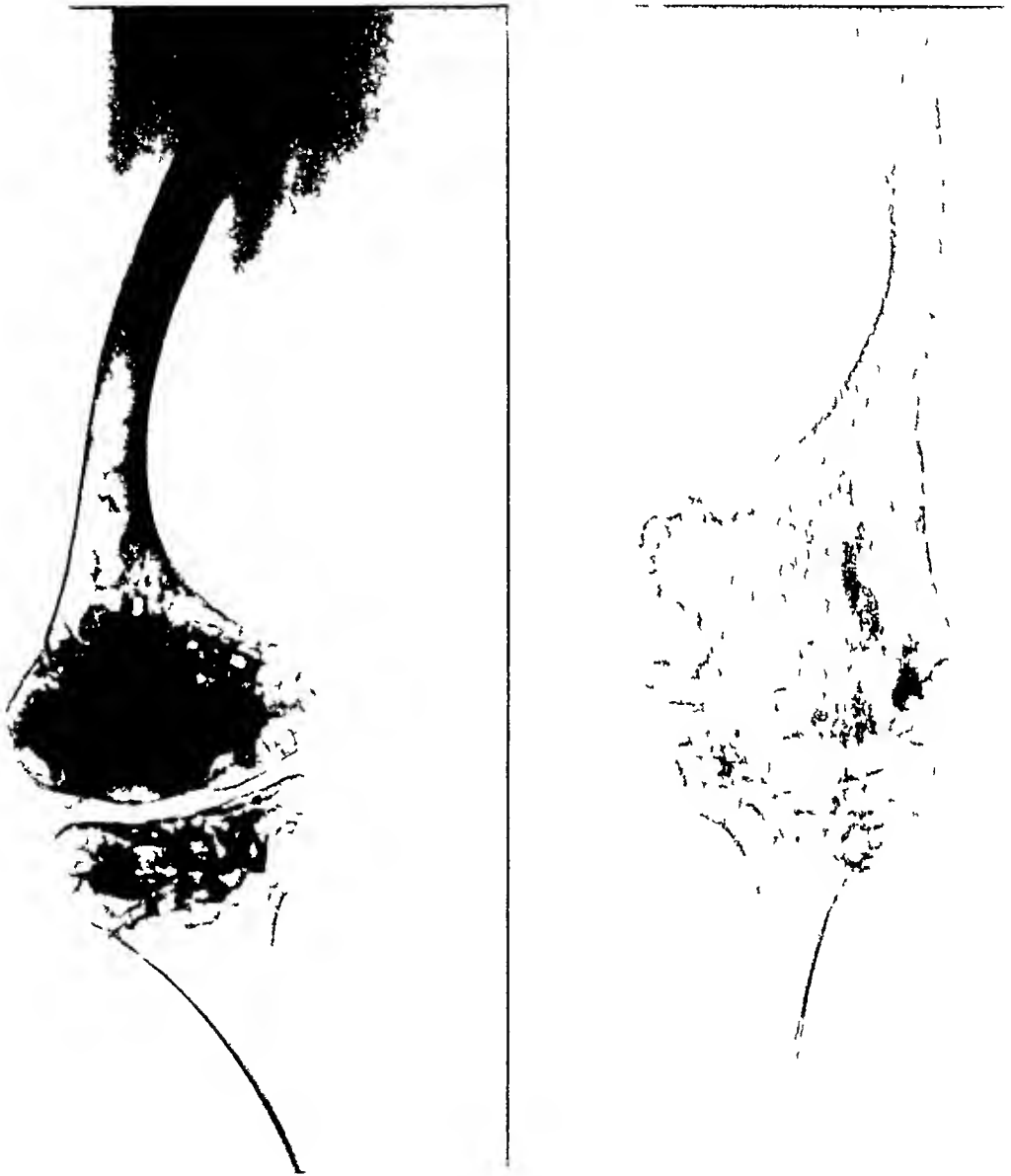


FIG 23

Case 11. Curious multiple circular opacities or rings in the metaphyses and epiphyses of the femora and tibiae adjacent to the two knee joints. Comparable changes were not seen elsewhere in the skeleton.

## CASE 12—OSTEOGENESIS IMPERFECTA CYSTICA

(Figs 24-33) Girl, seen at the age of five years, and again when eleven years of age

*Family history*—Father normal Mother, and several members of the mother's family, including her father, were said to have bluish sclerotics, but there was no history of bone fragility The patient was the third of five children, two have blue sclerotics without bone fragility, and the others are normal

*Clinical history*—History of many fractures, the condition was said to be congenital She was not deaf The sclerotics were not unusually blue The head was not of typical shape, there was no bulging in the temporal regions There was scoliosis Deformity of the pelvis was severe and apparently responsible for faecal obstruction when she was in hospital She could not walk but made good use of her arms

*Blood examination*—Red cells, 3.6 million White cells, 8.6 thousand Lymphocytes, 60.5 per cent Wassermann reaction negative Slight trace of albumin in urine but blood urea within normal limits Serum calcium normal (complete investigation of calcium metabolism was impossible) Phosphatase raised (1.42 units—normal 0.1 to 0.2)

*Radiographic examination*—Honeycombing was distributed throughout the whole skeleton but not in a uniform manner In the lower limbs it was fairly general, but in the upper limbs (at the age of five years) only the metaphyses were cystic This was strikingly so in the radius and ulna By the age of eleven years, when the condition appeared to have increased in severity, this distinction was much less obvious

*Microscopic examination of bone*—Microscopic sections of bone from the tibia show medullary spaces filled with loose vascular fibrous tissue

*Subsequent history*—By the time the child was eleven years old the deformities had become much more accentuated At the age of eighteen years the bone changes were universal, even the skull showing changes The girl died when aged twenty-three years



FIG 24

Case 12 Radiograph of tibia when aged 5 years Note the markedly cystic condition of the whole of the tibia and fibula The foot shows no special features

FIG 25

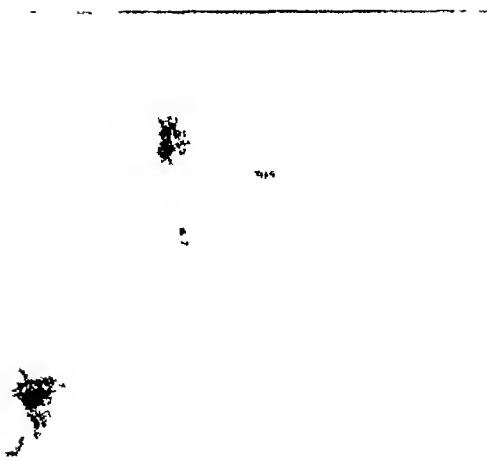


FIG 26

Case 12 Radiograph of femora and pelvis at the age of 5 years shows almost general cystic condition. There is marked deformity of the pelvis. The inset (Fig 26) is a microscopic section of a fragment of tibia showing the medullary spaces filled with loose vascular fibrous tissue.



FIG 27

Case 12 The grossly deformed child  
when aged 11 years



FIG 28

Case 12 Aged 11 years The whole of the shafts of radius  
and ulna and the bones of the hand are now affected



FIG 29

Case 12 Aged 18 years The upper limbs show generalised cystic changes in all bones with old and recent fractures





FIG 30

Case 12 Aged 18 years The hand shows almost universal changes



FIG 31

Case 12 Aged 18 years The lower limbs show gross cystic changes particularly marked at the extremities of the bones



FIG 32

Case 12 Aged 18 years Foot showing general changes



FIG 33

Case 12 Aged 18 years Skull showing irregular hyperostosis affecting both tables of the skull in the frontal and parietal regions

## CASE 13--OSTEOGENESIS IMPERFECTA CYSTICA



FIG 34

Radiograph of part of a skeleton in the museum of King's College Hospital. The history is unknown. Apparently of adolescent age. Multiple fractures, scoliosis and deformity of the pelvis are seen. The marked cystic structure of the bones seems to justify inclusion in the cystic class of osteogenesis imperfecta.

*Footnote*—Attention has been called by Professor S. L. BAKER to a very rare complication of osteogenesis imperfecta, namely, Hyperplastic Callus Simulating Sarcoma (Journal of Pathology and Bacteriology 1946 58, 609).

# THE ROBERT JONES TRADITION

G R GIRDLLSTON, OXFORD, ENGLAND

*From a Lecture given at the Wingfield Morris Orthopaedic Hospital Oxford June 1947*

Four or five years after I qualified, and knowing almost nothing about orthopaedics which at that time was little understood in the medical schools of London, I came across Robert Jones at Baschurch. Robert Jones himself was a great discovery, and what I saw at Baschurch was a revelation. Children suffering from tuberculosis of the spine or hip, whom I had seen in the wards and balconies of my teaching hospital—pale and suppurating, inherited from dresser to dresser, until they died of lardaceous disease, I found in this Shropshire village hospital in the best of health and spirits. I began going to Baschurch to accompany Robert Jones on his visits. It was rather like going to school again, a new kind of school in which the class was carried along at the pace and in the manner of the Master. Before long I found myself on the staff, and a little later I had abandoned general surgery, for I had found my job!

Two other people were concerned in the making of this tradition. One was Agnes Hunt, now Dame Agnes, to whom the hospital owed, and looked for, everything. She had started it and it was wholly hers, though she surrendered her dominion to Robert Jones when he was there. To be at work with him was a joy. You shared in his obvious enjoyment, and if you were quick enough you could lend a hand. But when you were working on her staff at Baschurch you had to *do your stuff* and like it, and go on liking it—more patients to see—more operations to do—till the work was done. Miss Hunt saw to that! The second was Hugh Owen Thomas whom I never saw. Born in 1834, he died in 1891 with body and mind burnt out by an eager and indomitable spirit. This spirit lived on in the much stronger frame of his nephew, Robert Jones, and Thomas contributed his full share to that potent brew which supplies the Robert Jones tradition with its strength and life-giving properties.

You will understand that this is not a clinical lecture, and that you must look elsewhere if you want to acquaint yourselves with the scientific and clinical contributions of H. O. Thomas and Robert Jones. The professional writings of Thomas are still of vivid interest. You should also read Dame Agnes Hunt's *Autobiography* (1938)<sup>1</sup> and her excellent little book on *Orthopaedic Nursing* (1923)<sup>2</sup>. My first purpose is to give you some conception of these three great characters. Then I shall try to penetrate the secret of their extraordinary skill, energy, and influence—that way of life which lies inside the Robert Jones Tradition.

My account of Robert Jones comes from long and intimate personal knowledge as disciple and friend, but I owe much to his *Life* by Frederick Watson (1934)<sup>3</sup>, his son-in-law, and to letters I have received from Hilda Watson his daughter, from McCrae Aitken, who, with Naughton Dunn and myself worked with him and for him at Baschurch, from Sir John Goodwin, D.G., R.A.M.C., 1918–23, and from a Robert Jones Memorial Lecture by Harry Platt (1943)<sup>4</sup>. I have also included extracts from the brief biography I contributed to the *Dictionary of National Biography*. Of Hugh Owen Thomas there are two complementary accounts—a *Personal Study* by Watson (1934)<sup>3</sup> and a presentation of his *Principles and Practice* by McCrae Aitken (1935)<sup>5</sup>. He also figures in that classical collection of brilliant and penetrating studies of *Menders of the Maimed* by Sir Arthur Keith (1919)<sup>6</sup>, a book which established the foundations of orthopaedic surgery, and is of extraordinary interest and value.

Robert Jones was born in Rhyl, June 28, 1857, the eldest child of Robert Jones, a journalist of London, and his wife Mary (*née* Hughes of Rhuddlan, Flintshire), and grandson of Robert Jones of Rhyl, an elder of the Welsh Methodist Calvinistic Church. His father was a man of great charm, and his portrait leaves no doubt as to the beauty and dignity of

1 *This is My Life* Blackie London

3 Hodder & Stoughton London

5 Oxford University Press

2 *Hall the Printer* Oxford

4 *British Journal of Surgery* 30, 291

6 Hodder & Stoughton London

his person. He was adored by his young son, and his early death from typhoid fever in 1875 put a tragic end to a growing friendship between father and son.

In 1870, three years before he left Sydenham College, his uncle, Hugh Owen Thomas of 11 Nelson Street, Liverpool, offered him a home if he should decide to study medicine. To the world's great good fortune he did come to this decision and accepted his uncle's invitation. So in 1873, aged 16, he left London for Liverpool. What a strange experience it must have proved! Hugh Owen Thomas was a genius of extreme individuality and an extraordinary way of life, he was original, autocratic, and solitary, he possessed a spirit of inquiry which was a perpetual challenge, he practised an intellectual austerity which was also a sleepless search for truth.

Robert Jones himself has given us this description of one of his uncle's typical days. "At six o'clock in the morning Thomas was already on his rounds, seated in a high phaeton built to his own design by his smith on the premises. Sitting at a great height and behind two beautiful horses he visited a dozen patients before breakfast." Before we follow Thomas on this early morning round, let us hear Watson's description of the equipage. "To his contemporaries, whether patients or the general Liverpool public, the spectacle of H. O. Thomas was one of the sights of the town. His diminutive figure tightly enclosed in an elaborate coat, his 'second mate's discharge' hat as seamen called it, pulled down over one eye, his tremendous gauntlet gloves, his cigarette, then quite a curiosity in itself—here was a Dickens character in everyday life. Place this unusual personage with his beautiful wife beside him in a very high home-devised chariot painted scarlet, and called not inappropriately the 'fire engine,' set two high-stepping black horses in the shafts (and sometimes tandem), and there was H. O. Thomas going his rounds.

"It often happens that when he knocks at the door, usually with his bare knuckles, an empty can is handed to him, but as a rule they know the knock. The patient may have a broken leg, intestinal obstruction, or pneumonia. There is always time for a cheery word of advice and admonition. If it is a broken thigh the extensions may want tightening, or pressure pads adjusting, and many warnings are sure to be given to the household that no bandage is to be meddled with. Another house is visited and he finds that the bandage has been loosened in a case of Pott's fracture. The surgeon storms and the patient is immediately penitent. He is no longer to be trusted, however, so the bandage is reapplied and a large pin fastens it, but before the surgeon leaves, a blob of sealing wax covers the pin, and with a signet ring removed from his finger it is sealed with the initials 'HOT'. Another visit and Thomas is seen carrying a boot into the house in one hand and a box containing enormous cutting shears in the other hand. He is about to transform a bed splint into a caliper in a case of tuberculous knee, for the time for walking has come. And so the round goes on until breakfast, which consists of a cup of tea and a couple of bananas. The meal rarely lasts for more than ten minutes.

"From nine until two he was at work in his room, where he meets with every variety of cases, both medical and orthopaedic. During the morning he will see between thirty and forty patients, prescribe and dispense medicine for them, dress their wounds, reduce their fractures and dislocations, and give each one his individual attention. Long experience on the surgical side has enabled him to make a rapid diagnosis and to ask only those questions which have a direct bearing on the case. So through all his cases one finds that Thomas has formulated principles, and diagnosis is based upon the relations of symptoms to them.

"His methods of examination, although rapid, are very gentle. He has wonderful knowledge of the movements that give rise to pain, and of the value of an accurate grip in steadying muscle and supporting limb. Whenever he has to handle a fracture he persuades the patient to abstain from all effort and to leave the muscles slack, knowing full well how often pain is self-inflicted. There is hardly a morning without one or two cases of fractures and these are always expeditiously dealt with without anaesthesia.

"The equipment of the establishment in Nelson Street is such that no outside aid is needed. There is a blacksmith at work in a smithy, a saddler finishing off the various splints, and the duties of others are the making of adhesive plasters and bandages, and the preparation of dressings. There are splints of every size to suit any possible deformity that may appear, or for any fracture that may have occurred. No matter from what distance a patient comes, no matter whether the affection be spinal caries, lupus disease, or fractured thigh, he is always able to return home in an hour or so, most accurately fitted with a simple and appropriate splint.

To see Thomas at work in his surgery was a liberal education. His mechanical knowledge was so profound and his observation so accurate that when a splinted patient appeared before him in discomfort there was no occasion for speech, the faulty spot was immediately pounced upon and corrected without delay. Although the examination was brief it was intensely concentrated and it was useless for either patient or assistant to ask any questions while it was in progress.

"Before starting for the afternoon round there may be a case of old dislocation of the shoulder waiting to be reduced, the displacement perhaps seven weeks old. It is now half-past two and people have to be seen at their homes without delay, for at four-thirty Thomas has a case at Nelson Street.

"His last meal finished, he hurried from the table to see his evening flock, who continued to come until eight o'clock. Although most of these were Club patients, quite a number were surgical cases, but the patients had more confidence in him than in hospital. In spite of his strenuous day he is bright and cheery, for he loves to chat with the working man on the character and scope of his work. Usually at eight he made his last round, confining his visits to those cases anxious in themselves, or interesting from the point of view of investigation. It was always an interesting round because compound fractures and intestinal obstruction were often encountered.

"From nine-thirty to twelve he either worked in his lathe-room—which was fitted with the most modern machinery, making new surgical instruments or repairing old ones, or he would find his way to the library to read and write.

"This then is an ordinary day's work, and to anyone who knew Thomas, with his frail body and anxious mind, entering wholeheartedly into his patient's troubles and always unsparing of effort, it is a marvel how he could work continuously at such pressure for over thirty years, for it must be remembered that he never took a holiday. During all these years of work he was only away from home some six nights, and even on Sunday mornings he had his free clinic, when nearly 200 cases, many of them of great interest, collected from all parts."

Beside all this arduous clinical work he managed to contribute to medical literature a series of books in which he set out his principles and his practice, illustrated by case reports, the whole conveyed in his own incisive, inimitable manner.

It was indeed well that his nephew was so vigorous that he managed to combine the arduous life of a medical student with an eager participation in his uncle's life and work—a part-time apprenticeship of great value, if of a restless and exciting quality. No doubt young Robert Jones owed more than he knew to his Aunt Elizabeth, who, serene, affectionate, and religious, fostered a homely atmosphere in 11 Nelson Street which without her cultured and kindly presence might well have proved unbearably restless and disturbing. Here Robert Jones grew up, absorbing into the soundness and strength of his nature the dominant passion for effective service, with a complete disregard of self, which burned so fiercely in his uncle's frail form.

In 1881 he was appointed Honorary Assistant Surgeon to the Stanley Hospital. In 1887 he married Susannah Evans, daughter of a well-known Liverpool merchant. Then in 1888 he became Consulting Surgeon to the Manchester Ship Canal. Platt speaks of this as "one experience in the early career of Robert Jones which, in its far-reaching consequences, might bring reassurance to those who see the life of an individual man

as a tiny part of the continuum of a larger design and purpose. In the early 1890's the citizens of the great cotton mart of Manchester vicariously carried through a feat of engineering which brought the sea some thirty miles inland to the heart of the city. During the construction of the Manchester Ship Canal nearly ten thousand men were engaged in the arduous and dangerous work of excavating the new waterway. There must have been men of intelligence and foresight in charge of this undertaking, for not only was the need for a casualty service realised from the first, but Robert Jones, the pupil of H. O. Thomas, was selected to organise and control this service.

"When fully developed, the Ship Canal accident service included a chain of first-aid posts and three receiving hospitals—wooden buildings, erected at strategic points between Manchester and Liverpool, each one in charge of a medical officer. The railway which ran along the line of the canal was also used for the transport of the injured men. Robert Jones himself often travelled by the little ambulance train when summoned by telegraph to deal with the most serious injuries.

"For four years this industrial battlefield provided a wealth of experience both in organisation and in the surgical treatment of accidents. In after years Robert Jones would conjure up from the stores of his memory—for no documented records had been preserved—a vivid account of this chapter of his life. He told us of the large numbers of amputations which were needed for severe crush injuries of the limbs, and how he had tried, but soon abandoned, the guillotine operation. Shock was treated by warmth, morphia, and hot drinks, and the mortality was surprisingly low. The Thomas splint was used, *secundum artem*, for the immediate fixation and transport of the lower limb fractures, thus foreshadowing its introduction some twenty-five years later to the battlefields of France. We thus see how it came to pass that when the Great War of 1914–18 flooded our military hospitals with compound injuries of the limbs, no other British surgeon had so much to offer to his fellow-countrymen."

In 1889 Robert Jones was elected Honorary Surgeon and Dean of the Clinical School of the Royal Southern Hospital. Suddenly in 1891 Thomas died, and Robert Jones was left alone in Nelson Street, face to face with "a decision upon which hung" as Watson reminds us "the whole future of British orthopaedics." He was now on the staff of the Royal Southern Hospital as a general surgeon, and Dean of the Clinical School. His future in general surgery was assured. Was he to confine himself to orthopaedics—or was he to adopt the more pleasant and profitable life of general surgery? Only those who sense the professional world in Liverpool at that time can appreciate the attraction that must have rested in the wider professional fellowship and greater scope of general surgery, especially to such a man as Robert Jones. Yet once again he made the right decision.

Sometime in 1900 Robert Jones the surgeon met Agnes Hunt the nurse, herself disabled by pain and persistent active tuberculous disease of the hip. She has described his impact on her life and wrote "His character was a delightful blend of impish mischief and splendid understanding, love, and charity. To us who were cripples he came as a refreshing breath from heaven, giving hope when hope was dead." From this association of Robert Jones and Agnes Hunt there came the first country orthopaedic hospital for crippled of every kind, with open wards in which fresh air, hope, and happiness combined to cure body and mind as one unit.

H. O. Thomas had laid the foundations, stated the principles, and given his nephew an amazing example of selfless service. Robert Jones followed Thomas in aiming at the relief of pain, illness, and disablement in the most practical and lasting way. Thomas preached "Rest, enforced, uninterrupted, and prolonged" as the foundation of sound healing. To us with all our systems of compensation, benefit and dole, it may seem that he over-emphasised rest and failed to advocate the "curative workshop" so highly valued by his great nephew and the "occupational therapy" so rightly nowadays to the fore. How he would have smiled at our ignorance! For much of his splintage was designed to enable men to go straight

on with, or quickly back to, the work which alone kept them and their families from starvation or the workhouse

Meanwhile events had been preparing Agnes Hunt for her part in the forging of tradition. She had been learning in the school of suffering and frustration. I believe that it took her eleven years to complete her nursing training, for she had active destructive tuberculous disease of the left hip, again and again the disease seemed to become quiescent, and she returned to her training, again and again recurrence of disease and pain laid her aside. All this no doubt, enabled Agnes Hunt to understand her patients in a way that nothing but personal suffering could teach. Thus, when she started her huts in Baschurch, she could set a standard of nursing care in which personal kindness was combined with the most practical and constructive skill.

Here she gathered round her girls of education and spirit to nurse the crippled children she had collected in this queer hospital, consisting of half-open huts in the rambling back premises of a house in a Shropshire village. Because she obviously demanded of herself more than was reasonably possible she could demand just a little less from these girls. The patients thrived, but the nurses wilted! Only the fittest survived—fittest in the best sense, for the "school" if hard, was good, and Sister Hunt kept a most perceptive and motherly eye on her nurses. Miss Hunt herself learnt the use of frames, splints, and plaster of Paris from Robert Jones, and then became a great artist in orthopaedic nursing by her powers of observation, and her determination that control should be accurate and effective without causing pain or discomfort. Many a time I have known her, at the end of a long day when everyone was very tired, go off on her crutches through rain and darkness to a distant hut to make sure that the splintage of some critical case was exactly right.

The very spirit of Baschurch was service—service to the patient both by surgery and by that most difficult form of nursing, the nursing of splints, frames, and plasters, the nursing of the paralysed and the spastics. It was expressed in skill, care, and kindness. The children caught from Miss Hunt courage and cheerfulness. Many an older patient found in her someone who had suffered as they were suffering, and who knew how to keep alive that inner fire of resolution which, glowing in secret within the crippled frame, forges the fragments of ambition into the Roosevelt or, indeed, the Agnes Hunt! We who worked with Robert Jones and Sister Hunt in the original Baschurch Hospital were very fortunate. Those were golden days. The tradition was in the foundry, white hot and spilling over!

You can imagine that life with these three was never dull. I believe that gleams of dour humour were often to be seen through the strange façade of Thomas. For instance, there is the story of the man with a badly dislocated shoulder which Thomas had reduced. When asked for a fee of 5/- for its reduction the patient demurred. "As you like," said Thomas, "we'll soon put it out again for you!" Of course Robert Jones was the best possible companion, infecting every gathering with gaiety and good humour. When the British Orthopaedic Association visited a country hospital he liked to arrange a game of cricket the moment the day's programme was over. As for Agnes Hunt she had the best possible sense of fun, and when she and Robert Jones were together things never remained serious for long, for mischief would keep breaking out. Their enjoyment of life was enhanced by their perfect freedom from pride, fear, and self-regard, those common sources of unhappiness. They had no "feelings" to be injured, no pride to be hurt, no resentments to "nurse", it was in their nature to prefer goodwill, good humour, and good manners. They had found something worth doing, and they did it with heart and mind and strength with heart for they cared intensely about it, with mind in that they thought and worked until every process was mastered, with strength in that they never stopped or slackened until the day's work was done. Of Robert Jones his residents were prone to say that he was all a great surgeon teacher, and friend could be, but that he possessed just one failing and from their point of view a grave one—he never seemed to know when to stop work!



Robert Jones and Agnes Hunt were great teachers both taught best by personal example, both had penetrating perception of the difficulties in the cure of deformity and the reasons for recurrence. They saw that if patients could be brought under effective treatment at the earliest possible moment the advance of deformity and disease could often be checked very quickly, and by simple gentle methods, and furthermore that the results would be much more nearly perfect than is possible at a later stage. In addition they knew that the best results would be made permanent only if cases could be kept under observation and continued care.

Miss Hunt, who was herself a countrywoman and had done for a time the work of a district nurse, knew that it was quite impracticable to expect patients to come long distances to an orthopaedic hospital until they were seriously ill and crippled, and that it was even more futile to expect a mother to bring one of her children from a rural home to the market town, then on by train to a distant hospital out-patient department, there to wait, eventually to be seen, and then to do the long journey in reverse. Neither early diagnosis nor prolonged after-care could possibly be achieved unless the specialist could be brought within easy reach of the patient. For this reason she originated the idea of clinics, scattered throughout the region served by the central orthopaedic hospital, and visited regularly by the orthopaedic surgeon and an after-care sister. Miss J. V. L. Brown was the first of these after-care sisters, and has always seemed to me the model on which all future after-care sisters should be built. She enlisted the help of the Medical Officer of Health to the County and they agreed that not only must the clinics themselves be organised, but that every step must be taken to teach—preferably by demonstration—doctors, midwives, Health Visitors, School Medical Officers, and, in some degree the whole population, the sort of case which should be sent to the orthopaedic clinic. The great advantage of the stitch in time in orthopaedic work should be emphasised, in order that early diagnosis may be achieved and expert treatment begun promptly.

But before all this could bear fruit there came the first world war. Within eighteen months Robert Jones had risen from Major to Inspector of Military Orthopaedics, in 1917 he was knighted and made a Companion of the Bath, in 1918 a Knight of the British Empire, and in 1926 a Baronet. The loss of Lady Jones in 1918 was a terrible blow and a lasting sorrow, but his daughter Hilda took her mother's place, and undertook such care as was possible of a man who was gone before eight o'clock and came back twelve hours later, hungry and tired at the end of a long day's work, often with a group of visiting surgeons!

During the 1914-18 war his teaching and influence spread not only in the Army but in the hospitals throughout Great Britain. He was immensely helped by a number of American orthopaedic surgeons led by Joel Goldthwait and Robert Osgood of Boston, Mass. In the field the Thomas splint had reduced the mortality of gun-shot wounds of the femur from 80 per cent to 20 per cent, and at home a great orthopaedic organisation had been set up. It was one of his major sorrows that soon after the war most of the units he had organised were dispersed. He made great efforts to preserve the Shepherds Bush Unit as a centre for orthopaedic teaching and research, but they were unavailing. The Baschurch-Shropshire prototype remained. Here at Oxford the Wingfield Hospital and its service in Berkshire, Buckinghamshire, and Oxfordshire was growing, but it was clearly necessary to multiply these units. In 1919 Sir Robert and I described our national scheme and its benefits in the *British Medical Journal* (1919, 2, 457) with the result that the Central Council for the Care of Cripples was set up. Thus a system of Regional Orthopaedic Hospitals and Clinics has grown up throughout England, and is growing in Scotland and Wales.

Each central hospital is linked with general and cottage hospitals, and scattered clinics serve every village in its region. This was indeed the first of the regional specialist services. In order to establish and maintain first-class services in any region it is necessary to secure the unstinted services of orthopaedic surgeons with a vivid interest in the care and cure of

crippled children To help them in their work they need after-care sisters of similar quality and training, expert in all orthopaedic treatment including the remedial use of plaster of Paris

The technical requirements of the orthopaedic surgeon and the after-care sister are, of course, important But certain personal characteristics are also required if the service is to be effective Both surgeon and after-care sister must be so keenly interested in the diagnosis and treatment of orthopaedic disabilities, slight or severe, that they are prepared to endure cheerfully a great deal of work which would otherwise be tedious drudgery, and throughout it all give both patient and parent the impression that they regard each and every case as of particular interest and importance Only in this way are patients and parents convinced of the necessity of carrying out exactly the instructions they are given only in this way are they content to take the trouble which regular attendance over a long period involves In the great proportion of cases professional interest is slight, because the case is recognised immediately by the expert eye, yet it is in these minor cases, and very numerous they are, that the prevention of disability can most often be achieved, and by simple measures which do not interfere with school life But such measures are successful only if they are carried out with enthusiasm as well as regularity How well Robert Jones knew all this McCrae Aitken, my colleague at Baschurch, writes "Though I cannot ever remember Robert Jones use the word psychology he was really very strong on the psychological side I remember one out-patient day when he saw four new cases of babies with congenital club foot Afterwards a house surgeon said, 'What a fraud Bobbie is! He talked to each of those mothers as if her baby was the most interesting case he had ever seen' That young man did not realise that to each of those mothers her own club-foot baby was the most important thing in the world"

Meanwhile honours were showered upon Sir Robert at home and abroad—the Liston Victoria Jubilee Prize, the Cameron Prize, and that rare honour the Distinguished Service Medal, U S A He was given honorary degrees by the University of Wales, McGill University, Montreal, Harvard and Smith's College, U S A, Liverpool University, and Yale, U S A He became without question the quasi-permanent President of the British Orthopaedic Association, an Honorary Member of the American Orthopaedic Association, and the First President of the International Society of Orthopaedic Surgery He received the F R C S of England "by election"

On his seventieth birthday he was asked to dinner by a company of his friends who had collaborated to produce the *Robert Jones Birthday Volume* (1928) as an expression of their admiration and affection It was a delightful occasion But his other friends were innumerable, among them Grenfell of Labrador, Joseph Conrad, Professor Blair Bell, Dr Charles Macalister, and Dr John Ridlon of Boston

He remained pleasantly immune to worldly wisdom He made friends equally with duke and docker He understood and enjoyed almost every form of sport, he was a formidable boxer in early manhood, and always delighted in a game of cricket Indeed he loved everything that brought men together in friendship Yet one had only to be with him in hospital to know that above all else his heart was in his work with an unfailing zest for the "case" a quick intimacy with the patient, and a way with children by which they knew at once how much he cared for them His heart was eager, gay, and generous, his mind receptive, deep, and sound, his hands strong, his touch light He was a clinician of unrivalled experience and resource, and an admirable teacher He had founded a new School of Orthopaedics, what is more, he had brought British orthopaedic surgeons together with a strong sense of fellowship We had become eager to learn, and as ready to discuss our failures as our successes for he had given us a true sense of values Sir John Goodwin well wrote "he was the soul of honour and integrity" Towards the end he spent much time in the lovely country of North Wales at Bodynfoel with his daughter Hilda and her husband, Frederick Watson, M F H And there on January 14, 1933, he passed peacefully away

Lord Moynihan, P R C S, colleague through the war and thereafter, contributed to the *British Journal of Surgery* (1933, 20, 545) an admirable appreciation of the surgeon and the man. He wrote "Robert Jones is dead. England parts in grief from one of her greatest surgeons and finest gentlemen, orthopaedic surgery loses the supreme master. It was a wonderful experience to visit Robert Jones and see him doing his routine hospital work. On arrival one was presented with a list of twenty-five operations to be performed! Robert Jones worked with almost incredible speed, and was supported by a team as efficiently trained as any one has ever seen. There seemed a silent conspiracy of united relevant effort in which every single person from surgeon to theatre porter took part. The surgical technique was flawless, there was none better in the whole world, and Jones enjoyed the distinction of being a fast operator whose technical methods had no weakness and did not give way under strain of speed. There is far too often a sacrifice of safety to haste, speed should be the accomplishment, not the aim, of an operator. As Jones worked, the clock seemed to be losing time. There was no slightest suspicion of hurry. One act followed another in due order without fuss, without delay, before one was prepared for it the list of operations was completed, and one began to wonder whether anything could conceivably go wrong with such superb unapproached mastery of diagnosis, of perfection in technique, of infinite resource. Many of Robert Jones' methods were of his own devising, he would employ, almost without one being quick enough to notice it, a device which alone would have made the reputation of another man. He would fashion a splint and make one feel that the pliant metal knew what was expected of it. He was, in fact, a consummate artist, in design and in accomplishment."

"It is impossible to tell truly of the love his patients bore him. He was greeted by the children in the open-air wards at Heswall, not with quiet respect but literally with a yell of delight. His manner to them all, his patience, tenderness, loving care, sweetness, and infinite gentleness, were a lesson to all. It may be doubted whether any man could win such love from patients as he did, his charm and kindness and compassion were infinite."

"Robert Jones was a man of great physical power. And he was above the tyranny of fatigue. He went from one task to another with the gay inexhaustible sprightliness of youth, and wherever he went men's hearts were lightened, their courage strengthened and their joy increased, their ideals made more glowing. He was the perfect friend. The kindly word, the cheering smile, the twinkling eye, the whole magnetic personality of Sir Robert Jones remains only as a memory."

In the chapel of the Shropshire Orthopaedic Hospital there is a tablet on which is engraved "To the Glory of God, and in loving memory of Robert Jones, Great Surgeon and Greater Man. Who devoted his life to the healing of the maimed and the cheering of the 'desolate'." And in the *Times* was written "The shining lustre of his name is an abiding glory to British Surgery, but it is the man himself whom his fellow-countrymen will wish to hold in remembrance."

### THE NEW ORDER OF ORTHOPAEDICS

Meantime the new order of orthopaedics, with its regional units of central hospital and surrounding clinics, had been growing. In 1919, Oxford and its three counties took shape, much on the Baschurch model. Other units soon followed, and the organisation in Britain is now almost complete. The system has been tested for twenty-five years and found to work. It is based on sound principles and made effective by early diagnosis, prompt expert treatment, and continued after-care.

1 Early diagnosis is made possible by including in the team field-workers of all sorts, in order to ensure early introduction of the potential cripple to the orthopaedic clinic,

2 Prompt expert treatment is given both in the out-patient clinic, and if necessary in the central orthopaedic hospital,

3 After-care field-workers and the out-patient team are relied upon to ensure and facilitate regular clinic attendance

We have proved that the system works all along the line, that disability is thus prevented, cured, or reduced to a minimum, and that derelicts, or would-be derelicts, are restored to active, enjoyable, and productive life. It is an essential part of the Robert Jones order of orthopaedics. You have been told of its origin—how it so happened that Robert Jones the medical student went to live with his uncle, Hugh Owen Thomas, the doctor son of a well-known bone-setter, how Robert Jones the orthopaedic surgeon met Agnes Hunt the nurse, how it so happened that each of these three had exceptional gifts, and had been prepared exactly by heredity, training, and circumstance for what was coming. It was as if they had been cast, chosen from all the world, for the parts they were to play. But it is not their genius, or their skill, or their possession of great gifts, that compel us to follow them. The Robert Jones tradition is vital! It lives because they used their gifts so generously and to such good purpose. Others have been as able. It just happened that these three loved their fellow-men, and put all they had at the disposal of those who needed their gifts

#### THE SOURCE OF THE TRADITION

Why did they do all this? What was their secret urge? I think it was loyalty to the work that had come to hand, a loyalty so strong that it amounted to a dedication like that of religion. To me as I look back, and it is good to realise that Dame Agnes is still very much alive, their loyalty to the work of healing appears a true response of spirit. Their reaction to suffering was immediate and practical like that of the Good Samaritan, which is only another way of saying that they were led by the Holy Spirit. I know well that Thomas, who was a devout atheist, would be deeply shocked at such a statement!

Loyalty to vocation and dedication of gifts—these are the secrets of the Robert Jones tradition. You may think it sounds suspiciously like "hitching your wagon to a star", yet in fact it is much more like "helping a lame dog over a stile" with the opportunity always at hand. One begins by going to school again, just as I had to do at Baschurch. I think that a good orthopaedic school is bound to be a hard school because there is so much to learn if the patients' troubles are to be understood, and their limbs held accurately and comfortably on the queer contraptions in the wards of an orthopaedic hospital. But I hope you have found out that this life-term school of orthopaedics, in which we all study and learn together, can be not only high in its standards, but happy in its team-work, its common aim, and the delightful human material on which its practical work of kindness and craftsmanship is done.

We set ourselves afresh, as they did long ago, to understand every principle and master every process of orthopaedics. They gave all they had got—"even all their living". That their gifts were of gold does not let us out. For we can be no less generous with our gifts of silver and copper—it is precisely this that the Robert Jones tradition demands from you and me, just as it was precisely this that Sister Hunt demanded of her staff in those golden days at Baschurch.

Like them we shall work with one common aim. We shall make ourselves expert at our job—nursing, physiotherapy, occupational therapy, workshops, whatever may be our position in the orthopaedic team. If we are to live and work in the Robert Jones tradition it means a strenuous life, for we shall set ourselves to do each job as well as possible for its own sake, but even more for the sake of the person who needs our help. We shall regard the whole person of our patient—the care, the cure, and the reablement of his body, mind, and spirit. For after all the whole thing exists for him. *He* must be helped. *He* must understand *what* is being done and *why*. You must see *his* point of view and *he* must know what you do, and that you are with him all the way back to health and active life again.

## Lister

Joseph Lister was born at Upton House, Essex, on April 5, 1827. For generations his family had belonged to the Society of Friends and the early influence of this body continued to govern his whole life. His father, J. J. Lister, was exceptionally versatile. He had considerable success in business in the city and somehow managed in his leisure to acquire a world-wide reputation for his researches in optics, which led to the perfection of the modern microscope, and his election to the Fellowship of the Royal Society. He also collaborated with Thomas Hodgkin in the publication of papers on microscopic observations of the blood and animal tissues. Furthermore he was an accomplished artist and a good linguist. From this it may be gathered that the young Lister was born into an environment highly favourable for the pursuit of science, and in his great quest he was destined to gaze at the amazing new world of micro-organisms through an apparatus perfected by his own father.

As a boy he was sent to private schools where he showed an early taste for natural science, and which led to his choice of medicine as a career. At the age of seventeen he entered University College Hospital, London, where he took his B.A. degree before proceeding to professional training. He proved himself a brilliant student, occupied a leading place in his own school, and took honours at the university examinations.

He was particularly attracted to physiology and was fortunate in his masters. Wharton Jones and Sharpey were inspiring teachers and at that time were laying the foundations upon which a succession of great investigators built a school of physiology at University College which became justly famous. Both these men taught him the scientific method of research. Wharton Jones, a prolific worker, was interested in the mechanism of the circulatory system and the stages of inflammation, for his investigations he used the frog's web and the bat's wing. Lister undoubtedly owed much to this master of research, he copied his method, in the use of web and wing, in his own later researches upon inflammation which led to the revolutionary discovery of the antiseptic principle in surgery. Sharpey was both friend and teacher to Lister and it was he who commended him to Syme.

Inspired by these two men, Lister, whilst yet an undergraduate, carried out original work on the involuntary muscle in the eye and skin. Kolliker had discovered that the iris consisted of involuntary muscle, and Lister, extending the research, found that it consisted of two separate muscles—the sphincter and the dilator. This particular work attracted considerable attention and led to a firm friendship between the two observers which lasted throughout their lives.

It was at this time too that anaesthesia was introduced into surgical practice. Sir Humphry Davy had worked on nitrous oxide in his laboratory, and from the narcotic effect of the vapour upon his own person declared as early as 1800 that the gas might have its uses in surgery, and in 1824 Henry Hickman of Ludlow proved its efficacy in operations upon small animals. At last Horace Wells in America used the gas successfully in his private practice as a dental surgeon, but when he attempted to demonstrate its use in general surgery he failed dismally and had to face pitiless ridicule. But in 1846 W. T. G. Morton, whom Wells taught, succeeded in inducing anaesthesia whilst J. J. Collins Warren at the Massachusetts General Hospital, Boston, removed a tumour from a patient. On December 21 the same year, Robert Liston at University College Hospital carried out the first operation under anaesthesia in England by performing an amputation through the thigh.

This was a memorable time—the birth of a new epoch in surgery—days to which men would look back. No longer need a patient be terrified at the whisper of an operation, nor a

Many influences have contributed to the development of orthopaedic surgery in Britain and it is intended by a series of papers to give some account of the part played by men and movements in this evolution. The dedication of British numbers will be indicated by a corresponding series of etchings on the front cover of the Journal. Separate copies of the colour prints are available on application.



Lister  
1827-1912

"For their work continueth And their work continueth,  
Broad and deep continueth Greater than their knowing"

RUDYARD KIPLING



surgeon be called upon to quash his feelings almost to the point of callousness. At long last surgery had become more humane. But surgery was not yet safe. Anaesthesia promoted adventure, but sometimes sadly disastrous adventure: the patient survived the operation but risked death from later gangrene or sepsis. However good a craftsman the surgeon might be he was, in the words of Volkmann, "Like a husbandman, who having sown his field waits with resignation for what the harvest might bring and reaps it fully conscious of his own impotence against the elemental powers which may pour down on him rain hurricane and hailstorm." And yet, strangely enough, actually looking on at Lister with wondering eyes was the very man destined for the task of making surgery safe.

At the proper time Lister qualified with the M.B. (London) and was appointed house physician and later house surgeon. In 1852 he gained the F.F.C.S. (England) and the next year went to Edinburgh with an introduction to Syme. The great Scottish surgeon received him cordially and there began a friendship between them which the years increased. Syme was one of the most original surgeons of his time and was an outstanding teacher. Lister became his house surgeon, reported his lectures to the *Lancet* and was a most enthusiastic pupil, eventually marrying his eldest daughter Agnes.

After a period assisting Syme in hospital and private practice Lister was elected, on October 13, 1856, to the post of Assistant Surgeon to the Edinburgh Royal Infirmary. He held this post for four years during which time he lectured on surgery, his teaching of which was suffused with pathology, for he held that students should have their knowledge built upon, and their reasoning stimulated by, a scientific foundation. At the same time he continued his researches, the fruit of which was embodied in papers read before the Royal Society. He gained a reputation as a first-rate investigator, a stimulating teacher, and a good operator, added to which he was transparently honest and modest.

In 1860 the Chair of Surgery at Glasgow University became vacant and Lister was appointed Regius Professor. He was soon lecturing to one of the largest classes of medical students in Britain, but what impressed him most were the limitations of surgery as a means of relief for human suffering, gangrene and suppuration were only too rife in hospital wards. It is difficult for us to imagine the state of affairs that prevailed. In the case of a compound fracture the scales were weighted on the side of the loss of life or limb. Hospital gangrene is to us a term in medical history but to our predecessors it was a perpetual black menace. Most surgeons were resigned to the occurrence of inflammation and suppuration in wounds and looked upon them as a natural and inevitable consequence of injury. But Lister, pained and distressed by the frustration of surgery, was unwilling to accept this fatalistic attitude and regarded "hospital diseases" as an evil to be overcome. More and more did his thoughts turn to their cause and prevention. His ideal of what should happen in a wound was what occurred in a subcutaneous injury, such as a simple fracture in which repair took place without inflammation, suppuration, or constitutional disease, and none was better placed or better equipped for the solution of this baffling problem. From early life he had been accustomed to the scientific attitude towards phenomena around him and he had been fortunate in the masters who trained him. When he arrived in Glasgow he was already mature as a scientific investigator, indeed among surgeons there was scarcely anyone so well equipped, he belonged to the Hunterian tradition.

Of his many papers embodying the results of researches, two in particular were of great significance, indicating the trend of his thinking and the preparation leading to the accomplishment of his great task. The study of coagulation of the blood attracted his attention for many years. This physiological phenomenon in the healing of wounds formed the subject of his Croonian Lecture before the Royal Society in 1863. In considering the pathology of the open wound he was led to the study of the genesis of inflammation. The later stages had been studied by other observers but information about the earliest onset was uncertain. Lister, with his microscope, observing the capillaries of the



frog's web and the bat's wing when they were subject to irritants of all kinds, accurately described for the first time the beginning of the inflammatory process. The vascular reaction to irritation was found to be produced indirectly through the medium of the central nervous system. This work he communicated to the Royal Society in 1857 in a paper entitled "The Early Stages of Inflammation". This particular study led him to regard putrefaction as the cause of suppuration and wound infection, decomposition was set up, though inexplicably, by the air. Such had been his teaching to students when in 1865 he became acquainted with the writings of Pasteur, and learned that putrefaction was a fermentation due to the growth of minute microscopical organisms which were disseminated by dust, blown about in the air, and which could also be found on all material objects. This was an astounding revelation, it was the opening of a biological new world of micro-organisms.

Lister soon realised that Pasteur's explanation of putrefaction was applicable to the decomposition of wounds. Already he had thought the air to be a contaminating influence and this view was now confirmed and the active agent revealed. The next step was to prevent micro-organisms from gaining access to the open flesh. To the attainment of this ideal, and to the perfection of its accomplishment, Lister dedicated the rest of his life. He started by casting about for a suitable antiseptic and on learning of the success of carbolic acid as a disinfectant in dealing with sewage at Carlisle he decided to give this chemical a trial in wound treatment. After investigation with the pure acid he finally adopted a 1 in 20 watery solution, and this strength of carbolic acid became a permanent feature of his technique. With this solution he cleansed his hands, his instruments, the patient's skin, and the wound itself. Lint soaked in carbolised oil was first used as a dressing but after many experiments was abandoned in favour of a putty made of carbonate of lime and a solution of 1 in 6 carbolic acid in linseed oil.

The result of this treatment upon abscesses and compound fractures was astonishing. Suppuration disappeared, wounds became healthy, patients were comfortable, the number of amputations diminished rapidly, and Lister was able to say "But since the antiseptic treatment has been brought into full operation, and wounds and abscesses no longer poison the atmosphere with putrid exhalations, my wards, though in other respects under precisely the same circumstances as before, have completely changed their character, so that during the last nine months not a single instance of pyaemia, hospital gangrene, or erysipelas has occurred in them. As there appears to be no doubt regarding the cause of this change, the importance of the fact can hardly be exaggerated."

His first paper announcing this new principle of surgical treatment appeared in the *Lancet* in 1867 entitled "On a New Method of treating Compound Fracture, Abscess, etc., with Observations on the Conditions of Suppuration". And the same year at a meeting of the British Medical Association in Dublin he read a paper on "On the Antiseptic Principle in the Practice of Surgery". It should be noticed that he stressed the principle and not the use of a particular drug in treatment, it was as though he foresaw that the method might change but that the principle was unchangeable. His constant aim was the prevention of sepsis in wounds, with the least irritation to the tissues.

From then on Lister's main purpose in life was to gain acceptance of the antiseptic principle as fundamental in the practice of surgery. The road he had to travel in gaining his objective was more arduous than he imagined. For some years his teaching was misunderstood and he had to meet violent criticism. Strangely enough many medical schools were indifferent, or accorded the doctrine a chilly reception. On the other hand well-known surgeons in France and Germany were not slow to see the merits of the antiseptic principle and he was encouraged by the enthusiasm of some industrial surgeons at home. The best missionaries of the new surgical learning were Lister's house surgeons and pupils. They had been witnesses of the principle in practice and with conviction they went out to preach the new doctrine. The rest of Lister's time at Glasgow was occupied in the observation

and recording of various diseases and injuries dealt with by the new treatment. He also introduced carbolised catgut for the ligature of arteries after testing it in the calf.

In 1869 he was elected to the Chair of Clinical Surgery at Edinburgh, in succession to Syme, and the students received him with enthusiasm. He became fully occupied with the duties of the Chair and of his large private practice, but in the laboratory in his own home he carried out endless experiments with the object of improving methods of carrying out the antiseptic principle and rendering its use in everyday practice more simple.

He remained in Edinburgh until 1877 when he was invited to a Chair of Clinical Surgery at King's College, London. The position he occupied in Edinburgh was far superior to the one offered him in London, but he was attracted by the great city itself and the opportunity it gave him of converting London schools to acceptance of the antiseptic principle, for hitherto it had made little headway there. He therefore migrated south, back to the city of his youth, where he had many friends who pressed him to come. He continued to occupy the Chair at King's College until 1892 and during these years perfected details of the antiseptic method and gave up the carbolic spray. He had the gratification of seeing his teaching accepted in London, and indeed throughout the world.

Acceptance of the antiseptic principle revolutionised the practice of surgery and led to phenomenal advance in all its departments. No branch of surgery felt the impact more than orthopaedic surgery. The introduction of subcutaneous tenotomy had been hailed as a great advance in the treatment of deformities, but it had strict limitations. With the prospect of safe open operations there dawned a new era of immense possibilities for the treatment of injuries, diseases, and deformities. Indeed the successful management of the compound fracture by Lister stands at the very beginning of the introduction of the antiseptic method. He pointed out that blood clot, protected by an antiseptic, would be organised by the ingrowth of cells and vessels from its vicinity, in this way callus was formed. He also explored the badly united fracture, reset the fragments and wired them. He was the first to explore simple transverse fractures of the patella and olecranon and to bind them with wire until union occurred.

In 1880, William Macewen of Glasgow, a pupil of Lister, operated upon a boy whose shaft of the humerus had been destroyed by osteomyelitis. He sewed tibial grafts along the former track of the bone and a new shaft was reproduced. Another pupil, Thomas Annandale of Edinburgh, in 1883 for the first time deliberately explored a knee joint for internal derangement and discovered an internal semilunar cartilage completely separated from its anterior attachment to the tibia. The cartilage was stitched back in its proper place, the man recovered perfect movement of the joint and returned to his work. For many years before Esmarch introduced his elastic bandage Lister had operated upon bloodless limbs. He would have a lower limb lifted as high as possible from the table and kept elevated for a few minutes, and then he applied a tourniquet at the upper part of the thigh. This provided a bloodless field for operation. He proved experimentally that blood left the limb not by gravity alone but also by reflex constriction of the arteries induced by stimulation of the vaso-motor nerves. This is still a valuable procedure, particularly when it is inadvisable to use an Esmarch bandage.

Lister retired from practice in 1896 but continued his scientific work. In the next year he was elected President of the Royal Society. Many other academical honours and foreign orders had been showered upon him. His appearance at scientific meetings in foreign countries had been greeted with triumphal acclaim. He was made a baronet in 1883, a peer in 1897, and was one of the original twelve members of the Order of Merit instituted in 1902. He died at Walmer in Kent on February 10, 1912. The universal and abiding value of Lister's work for the physical ills of mankind has made him one of the outstanding benefactors of humanity.

ARTHUR ROBYN JOYNS

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IN MEMORIAM

WALTER ROWLEY BRISTOW, M B , B S , F R C S  
1882-1947

Walter Rowley Bristow was born at Bevely, Kent, on December 12, 1882. He received his early medical education at St Thomas's Hospital Medical School where amongst his contemporaries and close friends were Charles Max Page, Gathorne R Girdlestone, and Godfrey Martin Huggins (now Prime Minister of Southern Rhodesia). During undergraduate years "Rowley"—as he became known to an ever-widening circle of friends in many different walks of life—was conspicuous for his athletic skill. He represented the hospital at lawn tennis, soccer, and water polo, and quickly became a scratch golfer. He was an early motorist, and being provided with an ample allowance by a generous father was able to indulge his hobby in a series of sporting cars. Unobtrusively, and with an apparent absence of effort, he passed all his examinations in due sequence and obtained the Conjoint Diploma of the Royal Colleges in 1907. One year later he graduated as M B , B S , in the University of London, and within two more years had successfully negotiated the formidable hurdles of the Primary and Final examinations for the F R C S (Eng). His first resident appointment at St Thomas's was that of house surgeon to Sir George Makins, this was followed by a term as senior house surgeon on the emergency block. Bristow's practical acquaintance with many forms of athletics and sport excited his interest in the treatment of injuries of the locomotor system and, more especially, in the neglected field of "sprain

and strains." By the time of the outbreak of the first World War he was well established in consulting practice in London. He had already entered into military commitments as Medical Officer to the Middlesex Yeomanry and served with this unit in Gallipoli, being mentioned in dispatches for his conduct at the Suvla Bay landing. He returned to England in 1916 to convalesce from an attack of the prevailing dysentery and by a happy conspiracy of events came under the notice of Sir Robert Jones who was then engaged in forming the staff of the Military Orthopaedic Centre at Shepherd's Bush, London. Bristow's primary appointment was to organise and take charge of the electro-therapeutic department, but he was soon added to the surgical staff, and then joined the small band of younger orthopaedic surgeons who were to become the devoted disciples of Robert Jones in the post-war years. At Shepherd's Bush, Bristow devoted much time and patience to the study of peripheral nerve injuries, and he made full use of the wealth of clinical and operative material which came his way. This led to his appointment on the Committee on Peripheral Nerve Injuries set up by the Medical Research Council. Ostensibly he was selected as an expert in after-treatment, for it brought him into contact with the minds of such men as Henry Head and Wilfred Trotter. Although Bristow was the first to disclaim any status as an academic it became evident that his mental processes were as acute as those of the intellectuals, and his keen intelligence pierced through a mass of facts to the essential principles of a problem. This faculty was to serve him well throughout his distinguished career and was to be one of his outstanding characteristics as a teacher and leader.

In 1919 St Thomas's Hospital set up an orthopaedic department. It was the end of an epoch and a breakaway from old tradition. Sir Robert Jones was invited to become Director of Orthopaedics at the hospital, and Bristow was formally appointed to the staff as Orthopaedic Surgeon. Sir Robert, then at the height of his powers and deeply immersed in his extensive practice and in public work, cast his mantle over the new department and left his younger colleague to build it up from small beginnings. This was Bristow's great chance. He had already learnt many things from his association and growing friendship with Robert Jones. One thing above all he saw clearly—that the head of a surgical clinic must become a leader of younger men. In this ambition he achieved an outstanding success, as witnessed by the quality of the men he attracted in turn as his chief pupils—George Perkins, E. P. Brockman, R. J. Furlong, and by the influence he exerted on many more who came to sit at his feet for shorter spells. Secure in his base at St Thomas's, he next looked out beyond the horizon of the orthopaedic department of a general hospital to discover a long-stay hospital without which no orthopaedic service was complete. At Pyrford in Surrey he found a cripples' home in ample grounds, well suited for the purpose. By adaptations and new buildings St Nicholas' Orthopaedic Hospital was gradually transformed into an active country orthopaedic hospital, at first limited to children, and later providing adult wards. In the second World War this hospital became an Orthopaedic Centre under the Emergency Medical Service, and it is to be known in future as the Rowley Bristow Orthopaedic Hospital, a fitting tribute to the life and work of its first surgeon-in-chief.

During the years between the two wars Bristow built up a large consulting practice. His patients came from far and wide, and amongst them were many men and women prominent in the public and social life of the nation. His practice was conducted in and from 102 Harley Street, a house which contained some beautiful examples of the work of Adam, most notably the ceiling in the front drawing-room. 102 was the scene of bounteous hospitality, dispensed with taste and grace by "Rowley" and his devoted wife. George Perkins has given a vivid account of a typical day at 102. "He (W. R. B.) breakfasted at eight and was in his office by eight-thirty. From then until seven-thirty in the evening, with a break for lunch, at which there was never less than one guest, he worked at top pressure, expending his own depthless energy and exhausting that of his secretaries. There followed a champagne cocktail and a change for dinner. Dinner was an occasion. He had one of the

best cooks in London, and could talk intelligently to any chef de cuisine on his subject" 102 alas is now a shell, blasted into ruins by the Luftwaffe

Bristow was an original member of the British Orthopaedic Association and served on the Executive Committee for many years. He was President during the years 1936-37 and infused the society with his dynamic leadership. A few weeks before his death he was accorded the rare distinction of Emeritus membership. He was in due course elected as a Corresponding or Honorary member of many foreign surgical societies—amongst them the American Orthopaedic Association and the French, German, Scandinavian, Australian, and Argentine Orthopaedic Societies. In 1937 he delivered the Hugh Owen Thomas Memorial Lecture in Liverpool, and in 1946 the Robert Jones Memorial Lecture at the Royal College of Surgeons.

In the second World War, after a period as a Regional Orthopaedic Consultant, Bristow was appointed Consulting Orthopaedic Surgeon to the Army and attained to the rank of Brigadier. This was his heart's desire—to recreate the orthopaedic service in the Army which Robert Jones had formed during 1914-1918. He was eager to don uniform again, and, in actual fact, his uniform from the first World War still fitted him. He gave most devoted and distinguished service to the Army, organising the orthopaedic sections of the military hospitals in Great Britain, selecting the young surgeons to take charge of this work, and visiting hospitals in the Mediterranean and Middle East. During these strenuous years he also flew to the United States where his visit will long be remembered. In 1946 the French Government appointed him Chevalier of the Legion of Honour and awarded him a Croix de Guerre with palm.

During his most busy years Bristow maintained a steady output of contributions to surgical literature. Two subjects held his interest throughout—disabilities of the knee joint, and injuries of peripheral nerves. His Robert Jones Memorial Lecture on the latter topic was a masterly exposition of the subject. As a teacher of undergraduates he was without rival in his own hospital. In G. R. Girdlestone's words "He taught well, penetrating to the heart of his subject and picking on the essentials with clarity and emphasis. His out-patient clinics at St Thomas's were stimulating, memorable, and crowded. They were alive with humour and humanity, for he never failed to feel and show a friendly intimacy with the Lambeth folk." Simplicity was his theme. Generations of Thomas's students will still recall such aphorisms as "We treat patients, not disease." He was *par excellence* the "good doctor."

It is difficult to realise that Rowley Bristow has gone from our midst whilst still at the height of his powers, for to his colleagues, his pupils, and his friends—all over the world—he was seemingly invulnerable. We had looked forward to his enjoyment of a long Indian summer, in which some of us, both young and old, might have continued to share his radiant spirit. In his genius for friendship, and in the ideal setting of his home and family life, we have lost something which is irreplaceable. When in the early part of 1947 he was called upon to face the beginnings of an illness which was soon to be declared mortal, he met the challenge of fate with the high courage and equanimity characteristic of the man he was. By his death international orthopaedic surgery has lost one of its outstanding leaders and British orthopaedic surgeons will mourn the passing of one of the most vital and dynamic personalities of our time—one who was in every respect a master surgeon.

In a brief memoir it is impossible to do justice to his manifold qualities—his amazing zest for work, for play, and for sport—each activity in its proper perspective. The words of Savage Landor, "I warmed both hands at the fire of life," tarnished perhaps by oft repeated quotation, gain new lustre when used to describe such men as Rowley Bristow.

#### AVE ATQUE VALE

Rowley Bristow married in 1910, Florence, only daughter of James White, LL.D., and they had one son and two daughters.

# PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

## GREAT BRITAIN

### LONDON CONFERENCE OF THE AMERICAN AND BRITISH ORTHOPAEDIC ASSOCIATIONS ON FUTURE DEVELOPMENTS OF THE JOURNAL OF BONE AND JOINT SURGERY

In the editorials of this number reference is made to the London Conference of representatives of the American Orthopaedic Association the American Academy of Orthopaedic Surgeons and the British Orthopaedic Association, held in the Royal College of Surgeons of England in Lincoln's Inn Fields on May 27 1947. The American Orthopaedic Association was represented by the President elect Dr R. I. Harris of Toronto the editor of the Journal Dr William Rogers and the late Dr Clay Ray Murray of New York. The Academy was represented by Dr Earl McBride of Oklahoma. The British Orthopaedic Association was represented by the President Mr George Perkins the Honorary Secretary Mr Philip Wiles Professor Harry Platt of Manchester and Sir Reginald Watson-Jones of London.

Mr George Perkins, being elected Chairman, opened the discussion and said that members of the British Orthopaedic Association had feelings of warm sentiment towards their friends in America who had proved more than helpful in offering the hospitality of their Journal encouraging British contributors promoting collaboration and even leaving out the word 'American' from the title of the Journal. But despite the sentiment which is still so strong in Britain, he said we must not put too much weight on this factor. Our purpose is not to emphasise the friendship which exists between Britain and the United States nor to discuss only the problem of orthopaedic publication in Britain. It is to develop the aim of creating an international journal which will represent orthopaedic surgery throughout the world.

**Agreed Principles**—After discussion which continued throughout the day it was agreed that certain principles should be submitted for the approval of the respective Associations, namely:

- 1) A Journal should be established representing the science and practice of orthopaedic surgery in the United States of America and the Commonwealth of British Nations with provision for the future participation of other countries.
- 2) The ideal journal for this purpose would be the Journal of Bone and Joint Surgery. The American Orthopaedic Association should be asked if they would be prepared to modify their journal to meet this need.
- 3) In order to mark this change of policy, the cover and title pages of the Journal should be modified suitably.
- 4) Two editorial boards should be appointed, one for the United States of America and one for the British Commonwealth of Nations.
- 5) The two editorial boards, or their authorised representatives, should meet at regular intervals, not less than once a year, for the purpose of determining general policy.
- 6) The number of annual issues of the Journal should be increased as from January 1948 or as soon thereafter as practicable. In the first instance four issues should be prepared, edited, published and circulated from the U.S.A. and four issues prepared, edited, published and circulated from the United Kingdom. The number of issues in future should be determined at joint conferences of the two editorial boards or their representatives.
- 7) All issues should be similarly produced, numbered, indexed and circulated to all subscribers, but allowance should be made for expression of the individuality of the British and American boards.
- 8) The Journal should be made financially self-supporting.
- 9-11) Administrative details, reviews of books, abstracts of current literature and other details should be the subject of future agreement between the two boards.
- 12) The principles of the present agreement should be binding for three years after which it should be re-examined.

Dr R. I. Harris at the conclusion of the conference said: 'This day's conversations have been of historic interest and in many respects unique. I speak for my colleagues in expressing appreciation to the British Orthopaedic Association for inviting us to share an occasion of such importance. I personally feel a heavy responsibility. My being here is the chance of being President elect of the American Orthopaedic Association. It happens that I am a Canadian standing between Britain and the United States of America and that makes my responsibilities heavier. We have discussed the solutions of a problem which has never been met before. I do not know of any journal of importance which has been published with international agreement such as we have considered.'

It may be that there are even greater obstacles to its solution than we have tried to visualise to date. It is even possible that the difficulties may be insuperable. The approval of the American Orthopaedic

Association will be given only after careful and critical examination. The Journal is their child created and nurtured by the ideals and efforts of their members. They will not concur to fundamental changes in editorial policy except for very good reasons. It is also possible that the agreement may not prove satisfactory to the British Orthopaedic Association; they may feel that they have not the liberty they wish. But in spite of administrative problems and divergence of interest we should attempt this co-operative effort. If it succeeds we shall have unique opportunities to influence the future of orthopaedic surgery. If by chance it fails we still can return to separate places without handicap.

Very considerable effort will be required of us. It will be well worth it. I would bespeak the interest of all who have taken part in the amicable conversations round this table to master the difficulties which must be faced.

Sir Alfred Webb-Johnson, President of the Royal College of Surgeons of England, who joined the concluding phase of the meeting said: Mr Presidents, I would like to say that I have found it a great privilege to be allowed to listen to part of your discussions to day. I knew that you were tackling a great problem, but I did not know that it had so many difficulties. I would like to give my blessing on behalf of the College to the conclusions you have reached. I am convinced that for the moment at all events, you have reached a wise decision. What the future may hold I do not know. We may not have a voice in determining the future, but after many years of constant co-operation between the orthopaedic surgeons of this country and surgeons on the other side of the Atlantic we should continue the effort of making joint presentation of achievement to the world. It would be a great pity if we failed. But even if this is so your efforts will not have been wholly in vain; you will have tried to achieve a working arrangement and we shall all remain friends. I am glad that you have been able to find in this College accommodation for your discussions.

### FIRST MEETING OF THE BRITISH ORTHOPAEDIC ASSOCIATION

Thirty years ago to day, in February 1918, the British Orthopaedic Association held its inaugural meeting at Rochester. In the latter part of the last century there had been a British Orthopaedic Society supported by a few surgeons and a National Orthopaedic Hospital, London, and publishing its own



INAUGURAL MEETING OF THE BRITISH ORTHOPAEDIC ASSOCIATION  
at Rochester February 1918

Reading from Left to Right—(Back Row) W. Irthow, W. Rowley, Bristow  
(Middle Row) Robert Osgood, I. P. McMurray, Blundell Bankart, McCrae  
Arken, Harry Platt, Reginald Elmslie, Laming Evans, Naughton, Dunn  
(Front Row) Tommy Openshaw, E. Muirhead, Little, W. E. Bennett  
Robert Jones was absent on military duty.

journal—Transactions of the British Orthopaedic Society. But that was a day of conflict between strong and forceful personalities. Tubby and Openshaw seldom met and if they did meet one or other was almost certain to boil with rage. Muirhead Little was too passive to succeed as peace maker. The Society died a natural death and the Transactions ceased publication in 1898.

To day, when the Orthopaedic Associations of America and Britain are rejoicing in a new agreement on joint publication, it is interesting to recall that it was Robert Osgood of Boston who succeeded in bringing together, round one dining table at the old Cafe Royal three of the four protagonists—Tommy Openshaw, Murhead Little and Robert Jones. Doubtless perhaps fortunately, Jones was abroad on military service. The inaugural meeting of the British Orthopaedic Association was held shortly afterwards. In the photograph taken at Roehampton which it is our privilege to publish we note with satisfaction the distinguished figures of Blundell Bankart whose energy and vigour to day is revealed in his contribution to these pages, Laming Evans whose benefaction to orthopaedic research is just unannounced Rowley Bristow whose recent death we much deplore and perhaps most youthful of all figures in the group the Chairman of our Editorial Board—Harry Platt who received the accolade of knighthood a few days ago.

#### LAMING EVANS BEQUEST FOR RESEARCH IN ORTHOPAEDIC SURGERY

Mr Laming Evans, surgeon to the Royal National Orthopaedic Hospital, who died a few days ago, left the residue of his estate of £50,000 to the President and Council of the Royal College of Surgeons of England to apply the income for the advancement of orthopaedic surgery. Mrs Laming Evans, who died more recently, left the residue of her estate of £10,000 to the Royal College of Surgeons of England to apply the income for research in orthopaedic surgery. The Council, including the President, Vice-Presidents Sir Harry Platt and Sir Philip Jones, is now considering how best to apply the two Laming Evans bequests to the advancement of orthopaedic surgery.

#### BRISTOW MEMORIAL LECTURE

Many friends of Walter Rowley Bristow have expressed the wish that a memorial to him should be instituted. It has been suggested that his life and work would be commemorated best by the institution of an annual or biennial Memorial Lecture to be delivered alternately if circumstances permit in Great Britain and the United States—the two countries in which he was acclaimed an outstanding leader in orthopaedic surgery and where he was held in such warm regard. When a sufficient endowment fund has been accumulated it will be entrusted to the British Orthopaedic Association. Contributions to this fund are invited and may be sent to George Perkins Esq., 149 Harley Street, London W.1, England.

#### HONOURS TO ORTHOPAEDIC SURGEONS

**Sir Harry Platt**—We learn with the greatest satisfaction that the New Year's Honours List includes the name of Harry Platt, Professor of Orthopaedic Surgery in the University of Manchester who becomes a Knight-Bachelor. He receives the accolade and is congratulated by His Majesty at the moment that this Journal is reaching the hands of its readers. Professor Platt has long been a distinguished leader of orthopaedic surgery in this country. His fracture service at Ancoats Hospital and later at the Royal Infirmary, Manchester was the achievement of a pioneer. His orthopaedic clinics have been the meeting-ground for surgeons from all countries who acclaimed his academic and intellectual distinction, his wide knowledge of orthopaedic literature and his friendship with surgeons throughout the world. During the war he was the able lieutenant of Sir Thomas Fairbank, moulding and developing orthopaedic units of the Emergency Medical Service and at the same time assisting to plan future regional orthopaedic developments through service on many advisory councils and committees. The British Editorial Board of this Journal is honoured by the distinction awarded to its Chairman—Professor Sir Harry Platt. As individual members we are delighted by the recognition of our friend Harry.

**Dr Philip D. Wilson, Honorary C.B.E.**—Philip Wilson was among the first of the American surgeons to arrive in this country during the war. He brought with him the American Hospital in Britain in which civilian and military casualties were treated for a long period before the United States was actually



Professor Harry Platt, Chairman of the British Editorial Board of the Journal, whose knighthood is just announced.



engaged in war A few months ago a telegram was sent from the British Embassy in Washington Dr Philip D Wilson 321 East 42nd Street N Y C It is with much pleasure that I inform you that His Majesty the King has been pleased to approve your appointment as an honorary Commander of the Most Excellent Order of the British Empire Lord Inverchapel, the Ambassador has asked me to convey to you his personal congratulations on this well deserved award Orthopaedic surgeons throughout this country join in offering their congratulations and their grateful thanks

**Samuel T Irwin of Belfast, C B E**—In the Birthday Honours List of 1947 is included the citation

*Samuel Thompson Irwin B A R U I M B B Ch B A O M Ch F R C S Ed Chairman of the Northern Ireland Medical War Committee to be Commander of the Civil Division of the most Excellent Order of the British Empire* No member of the British Orthopaedic Association has attended meetings more regularly than our good friend Sam Irwin who refused to be daunted by war-time difficulties of travel and succeeded in maintaining his almost unbroken record His honour is widely approved

#### **Appointment of Mr George Perkins as Professor of Surgery in the University of London, St Thomas's Hospital Medical School**

Mr George Perkins M C retiring President of the British Orthopaedic Association and President of the Orthopaedic Section of the Royal Society of Medicine who took so prominent a part in establishing the new Journal of Bone and Joint Surgery has just been appointed to the Chair of Surgery in St Thomas's Hospital Medical School of the University of London There is perhaps special significance in the fact that the appointment is that of professor of surgery and not professor of orthopaedic surgery We welcome



George Perkins recently appointed Professor of Surgery at St Thomas's Hospital Medical School lecturing on Amputations at the British Post-graduate Medical School at one of a series of courses arranged during the war

this recognition that the surgery of the locomotor system is based no less firmly upon the background of general surgery than the surgery of the viscera or any other specialty and that the well trained orthopaedic surgeon is no less competent to supervise the education of undergraduates than any other surgeon

With typical clarity of thought Professor Perkins identifies three successive objectives in training 1) the training of the general practitioner 2) the training of the general surgeon 3) the training of the specialist surgeon He believes not only that every specialist should first be experienced in the wide field of surgery but that his first visiting appointment to the staff of a hospital should be that of general surgeon—with promotion in due course to the specialist post of abdominal surgeon thoracic surgeon neuro-surgeon orthopaedic surgeon and so on He believes that the system of apprenticeship by which medical undergraduates are allocated as dressers to one surgeon for the whole of their training is no more than a relic of the past The individual best qualified to give instruction in a special branch of medicine is the specialist in that branch and it calls only for planning by the Dean of the Faculty and the Professors of Surgery and Medicine to see that various facets of specialist instruction are moulded and co-ordinated into a balanced training

## BRITISH ORTHOPAEDIC ASSOCIATION, ANNUAL MEETING, 1947

The Annual Meeting of the British Orthopaedic Association was held in Manchester on October 24 and 25, under the presidency of Mr George Perkins M.C. A symposium on Recurrent Dislocation of the Shoulder Joint was opened by Mr H. Osmond Clarke and Mr J. Crawford Adams (London). The contributions and discussions are published in this number of the Journal.

**Treatment of Osteomyelitis—Anatomical and Physiological Basis—***Professor Jacques Leveuf* (Paris) reported experience in the treatment of 600 cases of acute osteomyelitis and said that the first site of lodgement of staphylococci in haematogenous osteomyelitis was not usually the metaphysis but the mid-shaft of the bone in the neighbourhood of entry of the nutrient artery. In this region a cortical abscess formed usually with a small lamellar sequestrum. Spread was mainly towards the surface but also along the track of the artery and its branches producing further cortical lesions and secondary foci of infection in the medulla and metaphysis. Professor Leveuf had used plaster of Paris immobilisation for twenty years (*Revue d'Orthopédie*, 1947, tome 33), and he condemned bone operations especially metaphyseal drainage in the acute stage. He doubted the value of penicillin therapy except after surgical intervention. The soft tissue abscess should be drained between the fifteenth and twentieth days. Formerly the wound was left widely open but now with the aid of penicillin it was closed forthwith. Histological and radiographic evidence was presented in support of the contention that osteomyelitis even in children developed primarily in the shaft through embolism of the nutrient artery and spread only secondarily to the metaphysis. *Professor H. Platt* (Manchester) said that he found it difficult to discuss Professor Leveuf's provocative paper because he could not readily alter his view that in acute osteomyelitis of the long bones of children staphylococci reached the metaphysis by metaphyseal vessels: how otherwise could he explain the finding of pus on drilling the metaphysis, with no pus or exudate which grew staphylococci when the shaft was drilled at a higher level? We were of course familiar with osteomyelitis of the shaft which was shown so beautifully in Professor Leveuf's specimens but in this country at least primary diaphyseal infection by the route of the nutrient artery occurred only in adolescents and adults and seldom in children. Perhaps the disease was different in Professor Leveuf's great surgical clinic of the Enfants Malades in Paris. *Mr Birkett* (Nottingham) said that he distinguished three types of acute infection in children—diaphyseal osteomyelitis as described by Professor Leveuf of which he had seen two cases in the last six months; metaphyseal osteomyelitis in which proximity of primary infection to joints was proved by early onset of characteristic joint deformity and osteomyelitis of the new born in which multiple swellings, abscesses and epiphyseal destruction occurred without pyrexia. Mr Birkett discredited Professor Leveuf's observations as to the failure of penicillin therapy and said that if properly used recovery was complete even in Professor Leveuf's cases had reached the stage for incision of abscesses.

**The Histology of Callus—***Professor S. L. Baker* (first professor of osteo pathology in the University of Manchester) demonstrated a superb series of photomicrographs of callus. He said that in the healing of fractures the first sign of bone appeared within a week of injury in an area of gelatinous oedema in the mass of young connective tissue which replaced the fracture haematoma. This bone is of a type called woven bone because unlike the lamellar arrangement of adult bone it is laid down in an irregular interwoven pattern about the blood-vessels of young granulation tissue: the orientation of its trabeculae therefore followed the pattern of the vascular tree. Woven bone was formed rapidly as a means of primary union to be replaced subsequently by adult bone. The formation of cartilage in this early stage depended largely on mobility of the fragments. If this was considerable as in fracture of the ribs cartilage cell formation was considerable: most of it nevertheless was replaced subsequently by bone. If movement was still greater as in many fractures of animals cartilage cell formation was so excessive that the fracture failed to unite: a pseudarthrosis was formed with fibro cartilage covering the fracture surfaces. Woven bone was in due course wholly absorbed by osteoclasts and replaced by adult lamellar bone which could be formed only slowly, and only upon an existing surface of primitive bone. Whereas the trabeculae of woven bone in primary callus followed the haphazard plan of vascular distribution the strictly parallel lamellar arrangement of adult bone was in accordance with the lines of stress. *Mr B. L. McFarland* (Liverpool) confirmed Professor Baker's observations as to the prodigious excess of callus formation in certain cases of fragilitas osseum sometimes even simulating neoplastic activity. *Dr J. F. Brailsford* (radiologist of Birmingham) engaged in a somewhat unconvincing digression on the merits of radiographic diagnosis as opposed to those of histo-pathological study.

**Paraplegia in Cervical Column Injuries—***Mr Roland Baines* (Glasgow) reported twenty-two cases which he subdivided into: a) flexion injuries—dislocation 8, crush fracture 4, acute disc retropulsion 3; b) hyperextension injuries—dislocation 1, injury of arthritic spine 6. He discussed in detail acute retropulsion of cervical intervertebral discs, and hyperextension injury of the arthritic spine. As to the former he urged that cerebro spinal fluid block called not for skull traction but for emergency laminectomy. In hyperextension injuries of the osteo arthritic spine paraplegia occurred with little or no evidence of bone injury. These patients were all more than fifty years of age. In one at least there was a complete tear

of the anterior common ligament. The stiff arthritic cervical spine was unduly prone to hyperextension injury, and moreover the cervical lordosis and associated thoracic kyphosis aggravated the tendency to traction injury of the cervical cord which was the probable cause of paraplegia. *Professor Geoffrey Jefferson* (Manchester) while confirming many of Mr Barnes' conclusions kept an open mind as to the credit due to laminectomy for the recovery which often occurred after this operation.

**Management of Acute Ischaemia in an Injured Limb**—*Mr D L Griffiths* (Manchester) advocated a precise programme in the management of acute ischaemia due to arterial damage in an injured limb: 1) general investigation including determination of arterial blood pressure and haemoglobin content of the blood, 2) removal of all possible sources of arterial pressure including the discarding of all bandages, plasters and splints, 3) attention to the general condition of the patient and especially to the maintenance or restoration of blood pressure which may determine the fate of the limb, 4) reduction of the fracture by one but not more than one manipulation always recognising the danger of such manipulation, 5) operative exploration of the artery including arteriographic investigation, except in cases where damage was already irreparable as for example in occlusion for more than twelve to twenty-four hours, or damage of both anterior and posterior tibial arteries—exploration to include resection and ligation in the case of complete division possibly arterial suture or vein graft in the case of incomplete division, arterial resection in the case of extensive bruising but no resection for simple spasm of an artery or for any vessel with minimal damage which was probably still capable of conducting blood, 6) paralysis of the cervico thoracic or lumbar sympathetic system by local infiltration, 7) institution of other measures to improve the collateral circulation including cooling but not freezing the limb, warming the patient, administering morphine, alkalies and penicillin prohibiting tobacco but permitting alcohol. *Professor H J Seddon* (Oxford) referred to the difficulty of decision in the case of arteries showing minimal damage in some cases resection was subsequently proved to have been justified by the presence of a small thrombus within the vessel.

**Reduction and Splinting of Fractures**—*Mr John Chanley* (Manchester) illustrated by ingenious models the methods he used in instructing students as to the basic mechanical principles of fracture treatment. The principles were well known they were generally accepted, they were being taught in every medical school. Nevertheless the audience was spellbound.

**Causalgia**—*Mr C H Cullen* (Leigh, Manchester) reported twenty-four cases of causalgia due to war wounds. Of seventeen in which sympathetic block was achieved with 2 per cent procaine (novocaine) fourteen were for the time being completely relieved. For such, sympathectomy was the treatment of choice. In eight patients the results were uniformly good except in one where part of the stellate ganglion had been spared. Radiotherapy was of secondary value except in cases which did not respond to sympathetic infiltration when it was the treatment of choice.

**Fracture-subluxation of the Shoulder**—*Mr T J Fairbank* (Manchester and London) said that 115 fractures about the shoulder included twelve in which there had been radiographic evidence of downward subluxation of the humeral head. The subluxation was attributed to the gravitational effect of weight of the limb at a time when muscles were hypotonic. The displacement could be recognised clinically by the groove which developed between the acromion and humeral head—a groove which could be obliterated by active or passive lifting of the humerus or by recumbency. At follow-up, one year after injury the subluxation had sometimes disappeared but in other cases it had persisted for as long as three years or more. A triangular sling which supported the limb was believed to be preferable to a collar-and-cuff sling and a plaster-of-Paris spica was preferred to an abduction frame. *Mr Pridie* (Bristol) suggested that the subluxation might be due to traumatic haemarthrosis. *Sir Reginald Watson-Jones* (London) pointed out that similar subluxations occurred in tumours of the neck and upper shaft of the humerus where there was no traumatic factor and no haemarthrosis. The coincidence of gravitational pressure and muscle hypotonicity was no doubt the explanation but care must be taken in traumatic cases to distinguish primary subluxations which were part of the initial injury from secondary subluxations which were due to the treatment.

**Unreduced Pathological Dislocation of the Hip Joint due to Septic Arthritis of Infancy**—*Mr A F Bryson* (Manchester) excluded cases aged more than twelve months at the time of acute illness. The joint infection and dislocation usually occurred during the first nine months. Operations were performed in fifteen cases, all of which were unilateral. One was treated unsuccessfully by Colonna's arthroplasty. Of three treated by osteotomy, one became stable, but the other two showed progressive shortening and increasing flexion-adduction deformity. Arthrodesis was by far the most satisfactory procedure, the fusion being performed between trochanter and pelvis (the head and neck of the femur being destroyed) eleven patients were thus treated and sound bone fusion was achieved in eight—one only after secondary osteotomy. Arthrodesis should be deferred till the age of twelve or thirteen years because earlier operation was uncertain and there was danger of recurrence of flexion-adduction deformity. It had not been possible to correct shortening by weight traction but considerable correction could be secured at operation by extensive stripping of the upper end of the femur. In one case true shortening was thus reduced from three and a

half inches to one inch. The denuded bone surfaces were secured and fixed by means of a miniature three-flanged nail. Only one patient complained of low back pain after arthrodesis and that was eighteen months after operation in a patient aged fourteen years whose recreations included walking no less than forty miles in a day. (Manchester must surely hold the record for long distance recreational walking. At the clinical demonstration later in the day *three* other patients each with lower limb disabilities said that they enjoyed walking twenty-five or thirty miles in a day.) *Professor Jacques Leveuf* while recognising the excellent results which had been recorded, nevertheless advocated arthroplasty even for unilateral cases. *Mr R I Stirling* (Edinburgh) reported three cases in which he had transplanted the trochanter to serve as a new head and neck and constructed a new upper lip to the acetabulum. The trochanteric epiphysis had not grown as he had hoped, but the stability thus achieved had facilitated arthrodesis at a later age.

**End-results in Fracture of the Femoral neck**—*Miss E L Willis* reported 192 cases treated in the University Department of Orthopaedics at the Manchester Royal Infirmary with a mortality rate of 8 per cent within three months of injury. Fifty patients with subcapital and transcervical fractures were seen two or more years after injury in twenty-two the result was excellent in fifteen the result was poor and in thirteen there was evidence of avascular necrosis of the femoral head. Of seventy-four fractures treated by Smith-Petersen nailing forty-one showed radiographic evidence of bone union. Of seventy-nine basal and pertrochanteric fractures, fifty one were treated by well leg traction with union in forty-three there were twenty-three good clinical results among twenty eight patients examined more than a year after injury.

**Clinical Demonstrations**—At the Manchester Royal Infirmary a series of bone tumours were demonstrated by Professor Harry Platt. Mr Charnley demonstrated arthrodesis of the knee by Key's method and a series of primary spinal fusions accompanying hemilaminectomy and foramenectomy for prolapsed discs. Mr H Griffiths showed unusual arthropathies, pathological fractures and actinomycosis of the spine. Mr Poston and Miss Willis showed cases of epiphyseal dysplasia and Mr T J Fairbank demonstrated screw fixation for acromio-clavicular dislocation. The demonstration at the Salford Royal Hospital by Mr Sayle Creer, Mr S Milner, Mr Mangan and Mr C Brun included unusual fractures and dislocations, vascular injuries and congenital deformities, spinal osteotomies for spondylitis, arthroplasties of the hip, amputation of all toes for rigid clawing, quadriceps plasty for stiffness of the knee joint after fracture of the femur, arthrodesis and arthroplasty of the wrist and typical cases of neurectomy for Morton's metatarsalgia.

**Election of officers and members**—At the business meeting certain elections were made:

<i>Vice-President</i>	James Russell Glasgow
<i>Honorary Treasurer</i>	V H Ellis London
<i>Editorial Secretary</i>	H Jackson Burrows London
<i>Members of Executive</i>	Maud F Forrester-Brown, Bath
	Norman Roberts Liverpool
<i>Emeritus Fellows</i>	A S Blundell Bankart London
	W Rowley Bristow London
	Sir H A Thomas Fairbank London
<i>Honorary Fellows</i>	Professor S L Baker Manchester
	Professor Geoffrey Jefferson Manchester
<i>Fellows</i>	Morris Axford Auckland
	Cecil Fleming London
	R S Garden Preston
	G Hyman Leeds
	A A Macdonald Auckland
	W L Macdonald Sydney
	D Wainwright Stoke on-Trent
<i>Associate Members</i>	D M Brooks Oxford
	R C Howard Norwich
	P I Hywel-Davies London
	C C James Birmingham
	A E Jowett Taunton
	W J B McFarland Auckland
	W Michaels Coventry
	A McDougall Glasgow
	C M Murray Portsmouth
	G Rigby-Jones London
	Garthoven Williams Auckland
	J D Wilson Alton

**Spring Meeting, 1948, Quebec**—It is hoped that the Spring Meeting will be a combined meeting of the American Orthopaedic Association, the Canadian Orthopaedic Association and the British Orthopaedic Association to be held in Quebec on June 3, 4 and 5.

Dr R I Harris of Toronto is this year the President of the American Orthopaedic Association and it is particularly appropriate that during his term of presidency there should be a combined meeting of the American and British Associations on Canadian soil. It is hoped that many Fellows and Associate members attending the Quebec meeting will visit clinics in Canada and the United States of America.

**Robert Jones Prize Essay, 1950**—It was announced that the subject of the Robert Jones Prize Essay for 1950 will be Osteoarthritis of the Hip.

**Annual Dinner of the Association**—The Annual Dinner was held on Friday, October 24. The toast of the British Orthopaedic Association was proposed by the Dean of Manchester. Mr George Perkins, retiring President in his reply referred to new developments of the Journal of Bone and Joint Surgery paid tribute to Dr Clay Ray Murray—that gallant gentleman who gave the supreme example of disinterested service—explained proposals for the joint meeting of the American Canadian and British Orthopaedic Association in Quebec and acknowledged the success of the Manchester meeting—'one of the best meetings the British Orthopaedic Association has ever had because Harry Platt was batting on his own village green'. The toast of the guests by Mr B L McFarland was replied to by Sir William Fletcher Shaw who referred to the origins of orthopaedics as a cross between bonesetters and osteopaths embracing all that part of surgery which is curable and lucrative. The toast of the retiring President was proposed by Harry Platt who having been described by George Perkins as "Franco Platt," might be excused for his reference to the President's "impish wit" as well as to his courage and his ability as one of the best clinical teachers in British Orthopaedic Surgery.

### FELLOWSHIPS IN ORTHOPAEDIC SURGERY

**Nuffield Fellowships**—Ten Fellowships have been awarded with the object of assisting young orthopaedic surgeons in Great Britain to arrange courses of study in the clinics of Canada and the United States of America in relation to the forthcoming joint meeting of the British Canadian and American Orthopaedic Associations in June 1948. The Fellows appointed by trustees of the Nuffield Foundation, include

John Charnley	Manchester	James Patrick	Glasgow
F C Durbin	Exeter	Miss Marion A Pearson	Stanmore
James S Ellis	Basingstoke	E W Somerville	Oswestry
T J Fairbank	Alton	F G St Clair Strange	Canterbury
P H Newman	London	I S Smilie	Edinburgh

**Travelling Fellowships**—Two Travelling Fellowships in orthopaedic surgery have been awarded to

J Crawford Adams	London	Cecil Langton	London
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### DEGREE OF MASTER OF ORTHOPAEDIC SURGERY, LIVERPOOL UNIVERSITY

The course for the degree of M Ch Orth in the University of Liverpool was held in abeyance during the war. The second post-war course began in the autumn of 1946 and after fifteen months postgraduate study in the orthopaedic and fracture clinics of Liverpool, the associated country hospitals and the Hugh Owen Thomas Memorial Library twenty-five candidates sat for the examination in December 1947. The internal examiners were Professor T P McMurray, Mr Bryan McFarland and Mr Norman Roberts, the external examiner was Mr George Perkins. Nineteen candidates were successful.

Almond H G A	Liverpool England
Coleman G S	Sydney Australia
Commerell J J	Capetown, South Africa
Desai M D	Bombay, India
Dickie J	Midlothian Scotland
Fahrm W H	Vancouver Canada
Kaplan C J	Durban South Africa
Kerr J G	Southport England
Lucas, H K	Liverpool England
McMurray T B	Liverpool England
Miller, B F	Halifax Nova Scotia
Morgan N H	Sydney Australia
O'Malley, A G	Liverpool, England
Osborne G V	Liverpool England
Parke W	Liverpool England
Polonsky B	Johannesburg South Africa
Price T	Liverpool England
Roberts, G I	Liverpool England
Thayumanaswami, V R	Madras, India

**Hugh Owen Thomas Memorial Library**—The gift by Dr Winnett Orr (Lincoln Nebraska) of his Scrap Book—a volume which is not only of academic value but of intense historic interest is gratefully acknowledged by the Hugh Owen Thomas Memorial Library.

## ORTHOPAEDIC SECTION OF THE ROYAL SOCIETY OF MEDICINE

### Autumn and Spring Meetings, 1947-48

**Cineplastic Amputations**—*Dr Henry Kessler* (New York) addressed the section on the subject of Cineplastic amputations—an elaboration of a lecture given a few days previously to the British Council of Rehabilitation. He stressed that no one procedure or appliance was applicable to every patient. The fullest co-operation was essential and he preferred to perform such operations only when the patient requested it; he never urged the procedure. Excellent results were demonstrated in a cinematograph film. In subsequent discussion it was pointed out that such amputations were useless without the highly mechanised limbs which had been developed in the United States.

**Flat foot and Instability of the Longitudinal Arch**—*Mr George Perkins* in delivering his Presidential address emphasised that a foot may be flat without being unstable, particularly in infants and young children when postural muscle tone was not yet fully acquired. A foot was stable only when body-weight was transmitted through the centre of the subastragaloid-mid tarsal joint in which position the bone structure of the foot was self supporting without the aid of ligaments or muscles. The ligaments were 'watch dogs' prepared to give warning of strain, thus calling for the protective action of muscles. Four types of 'flat foot' were distinguished. Type 1 was due to delayed development of postural muscle tone and required only exercises and often as a placebo wedging of the inner border of the heels of boots. Type 2 was due to equinus deformity; lengthening of the tendo Achilles should be considered in boys but seldom in girls because it altered the shape of the calf and a raised heel was often sufficient. Type 3 was due to varus deformity of the forefoot, often necessitating forcible correction by manipulation and plaster for two or three months. Type 4 was the rigid flat foot with subastragaloid-mid tarsal arthritis, sometimes needing arthrodeses but without refashioning of the normal arches which was liable to cause intractable callosities under the first and fifth metatarsal heads. In the discussion which followed there was general agreement that when wedging of shoes was needed it should be confined to the heels.

**Rotating Wooden Frame for Plaster Beds**—At the November clinical meeting *Mr E. T. Bailey* demonstrated this frame, similar in principle to the Hey Groves turning bed and the Stryker frame but costing only £10 and weighing only sixty pounds.

**Sitting-standing Invalid Chair** was shown by *Mr V. E. Gull*. Similar in appearance to the standard self-propelling invalid chair, it could be connected to a power plug and when the patient switched on a motor connected to the chair it was slowly converted to an upright stretcher so that without deliberate effort the patient was raised from the sitting to the standing position. The chair has obvious application to patients with poliomyelitis and polyarthritis. It will be constructed by the Stanley Engineering Company at a cost of about £100.

**Clinical Meetings**—Clinical demonstrations by Messrs Crisp, Coltart, Snell, Batchelor, Nissen, Little, Epps, and Appley led to vigorous and lively discussion on such problems as Calvé's disease of the spine, amputation of toes for gross deformity with metatarsalgia, congenital bowing of the tibia and brachial neuralgia due to excision of the outer end of the clavicle for recurring dislocation. At a clinical meeting at the Lord Mayor Treloar's Hospital, Alton, Sir H. A. Thomas Fairbank gave an appreciation of Sir Henry Gauvain's contribution to orthopaedic surgery which will be published in the next number of the Journal.

### LONDON MEDICAL EXHIBITION, 1947-48

The London Medical Exhibition which was suspended during the years of war has been revived and was held from November 1947 to January 1948 at the Royal Horticultural Hall, Westminster. On the two hundred odd stands were exhibitions by many firms of every new drug, compound, appliance, instrument, and book. All the latest orthopaedic devices originating in Great Britain, the British Commonwealth, the United States of America, and Europe were on view.

### SURGEONS' CONFERENCES OF THE MINERS' WELFARE COMMISSION, 1947

The third and fourth biannual conferences of surgeons engaged in England, Wales, and Scotland in the rehabilitation of injured miners were held in the summer at Oakmere Hall Rehabilitation Centre, Cheshire, and the Manchester Royal Infirmary, and in the autumn at Firbeck Hall Rehabilitation Centre and the Sheffield Royal Infirmary. Discussions, symposia, papers, and demonstrations, some of which will be abstracted in the next number of the Journal, included:

**Redevelopment of Muscle Function**—*E. A. Nicoll* (Mansfield). Discussion by *A. O. Parker* (Cardiff), *C. H. Cullen* (Leigh), *L. Morris* (Leicester), *Sir H. A. Thomas Fairbank* (London), *F. G. Strange* (Canterbury). Demonstrations by members of the remedial staff (Oakmere Hall).

**Excision of the Carpal Bones**—*C. H. Cullen* (Leigh). Discussion by *Savile Creer* (Manchester), *F. C. Dwyer* (Liverpool), *A. O. Parker* (Cardiff) and others.

**Soft Tissue Injuries round the Shoulder**—*C. H. Cullen* (Leigh).

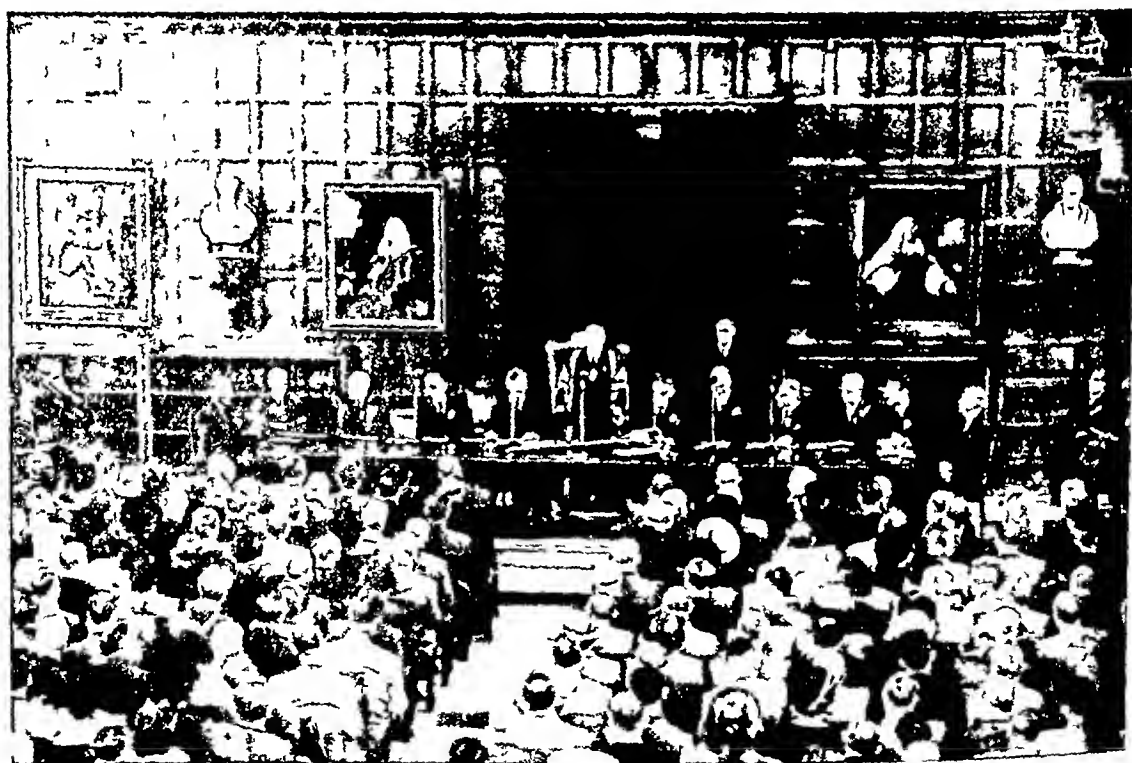
**Traumatic Paraplegia**—*E. A. Nicoll* (Mansfield), *F. W. Holdsworth* (Sheffield) and *Professor H. Platt*.

**Lactic Acid Treatment of Chronic Arthritis**—*I. McIver*. Discussion by *J. V. Todd* and *Savile Creer*.

Causalgic Syndrome—C H Cullen (Leigh) Discussion by Lloyd Griffiths and Professor Harry Platt  
 Pain down the Arm—D L Griffiths (Manchester)  
 Experiences with Meniscectomy—J Charnley (Manchester)  
 Radiographic Changes in Knee Joint after Meniscectomy—T J Fairbank  
 Bone Tumours—Exhibition—Professor Harry Platt (Manchester)  
 Suture of Olecranon—Exhibition—T J Fairbank (London)  
 Fracture Teaching Models—Exhibition—Sister Davidson (Manchester)  
 Dislocation of the Hip and Fracture of the Spine—C H Cullen (Leigh Manchester)  
 Tendon Surgery—G Pulvertaft (Derby)  
 Mallet Finger—W Gissane (Birmingham)  
 General Hand Injuries—S Pappworth (Sheffield)  
 Joint Stiffness after Trauma—Symposium opened by F W Holdsworth (Sheffield) A Dornan (Sheffield),  
 W H Maitland Smith (Doncaster)  
 Internal Fixation of Fractures of the Forearm—F W Holdsworth (Sheffield)

### INTERNATIONAL SOCIETY OF SURGERY, 1947

The Twelfth Congress of the International Society of Surgery—the first post-war congress—was held in London in September 1947 under the presidency of Dr Leopold Mayer and was attended by representatives from over forty countries. At an inaugural ceremony in the Great Hall of Lincoln's Inn, Sir Alfred Webb-Johnson, President of the Royal College of Surgeons, received the delegates, conveyed a message from His Majesty the King, and delivered a speech of welcome. By virtue of our calling," he said, "we are all patriots of humanity and know no frontiers, but by virtue of our citizenship we are



INAUGURAL CEREMONY of the International Society of Surgery in the Great Hall of Lincoln's Inn, September 1947

also ambassadors and can help to promote peace, concord, and understanding between nations. Replies were made by Professor Reynaldo dos Santos, Professor Jean Verhoogen, and Dr L. Dejardin. Receptions were given by His Majesty's Government at Lancaster House, by the President and Council of the Royal College of Surgeons of England at Lincoln's Inn Fields, by the President and Council of the British Medical Association at B.M.A. House, by Sir Gordon and Lady Gordon-Taylor at the Royal Society of Medicine, and by Sir Hugh and Lady Latt at the Hall of the Society of Apothecaries. Professor Grey Turner, elected next President—At a General Assembly of the Society, Professor Grey Turner (London—recently retired from the British Postgraduate Medical School) was elected President of the Thirteenth Congress to be held in New Orleans in October 1949.



**Conferment of Honorary Fellowships**—Three distinguished members of the International Society were admitted as Honorary Fellows of the Royal College of Surgeons of England—Dr Leopold Mayer (Brussels) Professor Victor Veau (Paris), and Professor Danis (Brussels)

Discussions were held throughout the week in the Great Hall of British Medical Association House

**Operative treatment of fractures**—*Professor Danis* (Brussels) showed a film illustrating the use of his special fracture operating table and of many ingenious devices for internal fixation, including a coaptation plate which impacted the fragments *Dr Phemister* (Chicago) discussed his technique for bone grafting by the onlaying of a graft without screws or other internal fixation, and without disturbing muscle attachments, fibrous tissue or existing callus He reported eighty-nine cases with primary healing in eighty-five there was failure of union in four which were cured by secondary operations except in one case of congenital pseudarthrosis *Dr R Demel* (Vienna) described the treatment of ununited gunshot fractures by the splintering method of Kirschner *Dr Westerborn* (Gothenburg) advocated intramedullary nailing for fractures of the femoral shaft

**Arteriography in the diagnosis of osteomyelitis and neoplasms of bone**—*Professor dos Santos* (Lisbon) gave a masterly review of the use of arteriography and venography in differential diagnosis In osteomyelitis the arteriograph showed obliteration of vessels within the infected area of bone, but with an abundance of vessels in neighbouring soft tissues In bone tumours, on the other hand the arteriograph showed intense hyperaemia both inside and around the lesion

Other discussions included *The Role of Penicillin in Surgery* opened by Professor Sir Alexander Fleming (London) and Sir Howard Florey (Oxford) and followed by some, but far from all the thirty speakers listed for discussion *‘Recent Advances in Surgery due to Heparin’* opened by Dr Crafoord (Stockholm) and Professor Galhe (presenting the work of Gordon Murray and C H Best of Toronto) *Repair of Skin Defects by Pedicle Flaps and Free Grafts* opened by Professor Kilner (Oxford) and *‘Vasodilatation in Arterial Disease’* opened by Dr Diez (Buenos Aires) and followed mainly by the French surgeons

**Clinical demonstration at the Postgraduate Institute of Orthopaedics**—Among a series of clinical and operating sessions arranged by the staffs of most of the London hospitals was a clinico pathological demonstration in the Postgraduate Institute of Orthopaedics at the Royal National Orthopaedic Hospital including repair of fractures in Paget’s disease (Rocyn Jones), endothelial sarcoma of the thigh (V H Ellis) changes in the plantar digital arteries in Morton’s metatarsalgia (K I Nissen), fat embolism (P H Newman), spinal osteoporosis of unknown origin (H Jackson Burrows) myeloblastic multiple myelomatosis, and vitamin resistant rickets (F Harwood Stevenson) In a series of technical contributions Mr A Rocyn Jones showed patients illustrating the use of transplanted cancellous bone in the treatment of non-union of fractures in arthrodesis and in obliteration of infected bone cavities Mr A T Frupp demonstrated results of medial and inferior capsulotomy of the astragalo scaphoid joint (Brockman’s operation) for club foot Five patients were shown by Mr I Trevor with rupture of the extensor pollicis longus tendon due to Colles’ fractures in which he had bridged the gaps with simple Bunnell sutures of No 6 nylon the results as observed over periods of six months to two years were excellent Mr D V Mathews discussed the use of the cross-leg flap for skin defects below the knee, and demonstrated an apparatus for linking the crossed legs through the medium of a universal joint

**Exhibition of instruments and books**—One of the most attractive features of the Congress was the exhibition of instruments, appliances and books at University College It was very well organised and well attended each day

#### INTERNATIONAL CONFERENCE OF PHYSICIANS, 1947

The International Conference of Physicians was held in London in September 1947 A symposium on pain was opened by Professor E D Adrian (Cambridge) and various speakers including Professor Henry Cohen (Liverpool) dealt with the problems of cutaneous and deep pain visceral pain and the relationship of visceral to somatic pain Social medicine the development of geriatric services and the care of the aged crippled were discussed by Sir Wilson Jameson and Sir Ernest Rock Carling (London)

**Mr Winston Churchill and the Medical Profession**—At a dinner held in the Guildhall Mr Winston Churchill as the guest of honour proposed the health of The Medical Profession He referred to the fearful journey we have all made since the Conference of Physicians last met in London in 1913 But to night,” he said all our thoughts are turned to healing and not destruction, and we can unfeignedly and unreservedly rejoice in the progress of medicine, and of its close and faithful companion surgery Medical science and surgical art have advanced unceasingly and hand in hand The medical profession at least cannot complain of unemployment through lack of raw material The genius of mankind is stirred and spurred by suffering and a long succession of noble discoveries in the application of the healing art stand forth with all the greater brilliance against the dark and hideous background of hatred and chaos The miseries of the population have given opportunities to the medical profession of rendering service to their fellow mortals on an unexampled scale There is no profession or calling whose members can feel greater or deeper conviction of duty There is no profession in which they can feel a surer confidence in an expanding future



Mr Churchill suggested the advisability of a hagiology of medical science and said that we ought to have Saints' days to commemorate the great discoveries which have been made for all mankind and perhaps all time. Nature like many of our modern statesmen, is prodigal of pain, and I should like to find a day of jubilation and praise of good St Anaesthesia, and of just and pure St Antiseptic. I would not venture in a company so distinguished to pretend to any qualifications to judge who should figure in this list, but if I had a vote I should feel bound to celebrate, among others, St Penicillin, whom I see represented here and St M and B both invaluable figures to whom I was introduced during the war in good time by Lord Moran, and without whose benedictions I might be regarding your present troubles, if not otherwise preoccupied, from a more serene sphere. Go forward then, gentlemen, members of this great vocation upon your upward path and forge for ever greater, sharper and more powerful weapons against the suffering and weakness which afflict us here below."

Lord Moran in reply referred to the fact that Mr Churchill was a Fellow of the Royal College of Surgeons of England and said that he had the two characteristics of the scientific mind—fertility of ideas and insatiable curiosity. As to the former, President Roosevelt had said 'He has about a hundred brilliant ideas a day and four of them are good' and there was evidence of his curiosity in the fact that Mr Churchill had proved to be an extraordinarily inquisitive patient. In conclusion, Lord Moran said that he had looked for a prescription for the social malaise of our time. 'I find that Pascal, writing in 1655 said that most of the evils of life arise from a man being unable to sit still in a room. Thought is still the prerequisite of sound action. Ages of quiet, sedentary, thinking men have done what is worth doing in the world. It is a matter for regret that owing to the increasing tyranny of routine leisure has gone out of the lives of men in the learned professions so that they are in danger of losing their culture.'

### ROYAL COLLEGE OF SURGEONS OF ENGLAND

**Moynihan and Hunterian Lectures**—After the conclusion of the meetings of the International Society of Surgery in September 1947 a series of Moynihan and Hunterian Lectures were delivered each day for ten days in the Royal College of Surgeons of England. Professor W E Gallie of Toronto, Past-President of the American College of Surgeons and recently elected President of the American Surgical Association, gave his Moynihan lecture on Recurrent Dislocation of the Shoulder which is reported in this number of the Journal. Lectures were given by Dr Arthur Allen, President of the American College of Surgeons, Dr Frank Lahey of Boston, Past-President of the American Medical Association, Dr Evarts Graham of Washington, Past President of the American College of Surgeons and of the American Surgical Association, Dr Alfred Blalock whose audience of between one and two thousand so strained the accommodation of the bombed Royal College that a repeat performance was necessary, Hassan Ibrahim of Egypt and Harold Wookey of Toronto.

During this period the most exclusive emblem of merit of the College, the Honorary Gold Medal, awarded only on twenty-two occasions since it was first struck in 1802, was presented to William Edward Gallie of Toronto, a Fellow of the College of thirty years standing. Immediately after the presentation a

cablegram of congratulation from his colleagues in Toronto and Canada was read. The Lister medal was presented to Dr Evarts Graham (Washington). The Honorary Fellowship of the College was conferred upon Dr Dallas Phemister (Chicago), Dr Arthur Allen (Boston), Dr Irvin Abell (Chicago), Dr Frank Lahey (Boston), and Dr Alfred Blalock (Johns Hopkins).

**Award of Hon F R C S Eng to Dr Dallas Phemister**—In presenting Dr Phemister to the President Sir Hugh Curns said: Dr Phemister has made outstanding contributions to the pathology of surgical shock and lesions of the bones and joints. His work on aseptic necrosis of bone is a classic in its comprehensiveness and in its use of the experimental clinico-pathological approach. Some twenty years ago Dr Phemister gave up a successful career as a practising surgeon to found a whole-time department of surgery in the University of Chicago and it is a matter of satisfaction to us that in preparation for this mission he worked for the greater part of a year in the department of physiology in University College, London. His work is outstanding and also the work of his associates. Here is a surgeon who stands out in his generation as a successful exponent of the ideals of John Hunter whose work stimulates our American colleagues no less than us of this College, and gives us vitality and inspiration."



Dr Dallas Phemister, Chicago awarded the Honorary Fellowship of the Royal College of Surgeons of England

**Lectures in the Royal College of Surgeons**—Lectures on Surgery Pathology, Applied Anatomy and Physiology, the Hunterian, Arris and Gale and other statutory lectures and special courses of lectures given in the Royal College of Surgeons of England during December 1947 and January 1948 included

December

- 3 Flexor and Extensor Retinacula of Wrist and Ankle—H F Lunn
- 3 Pathology of Tuberculous Infection—Professor G P Wright
- 4 Vasodilatory Nerve Mechanisms—W Feldberg
- 8 Source and Transmission of Wound Infection—Professor R Hare
- 9 The Elbow Joint—E L Patterson
- 11 Pathology of Poliomyelitis—Professor R J V Pulvertaft
- 12 Acid-Base Balance of the Blood—G A Harrison
- 16 Absorption and Deposition of Bone—Professor S L Baker
- 17 Autonomic Nervous System—Professor J Beattie
- 17 Surgical Tuberculosis of Bovine Origin—Professor Blacklock
- 19 Calcium Metabolism—Dr Douglas Robertson
- 19 Myelomata and the Haemopoietic Bone Marrow—Hamilton-Pearson

January

- 14 Bone Growth—Sir Reginald Watson-Jones
- 15 Pyogenic Affections of Hip and Knee Joints—V H Ellis
- 15 Bone Growth—Professor H A Harris
- 15 Physiology of Anaesthesia—E A Pask
- 16 Congenital Dislocation of the Hip—A Roodyn Jones
- 19 Fractures Involving the Knee Joint—F W Holdsworth
- 19 Reactions of Bone to Injury—Professor S L Baker
- 20 Congenital Deformities of the Foot E P Brockman
- 21 Muscle and Tendon Ruptures—R Broomhead
- 22 Postural Deformities of the Spine—E P Wiles
- 23 Ankle Joint Fractures—A J Watson
- 26 Static Derangements of the Foot—H J Burrows
- 27 Brachial Plexus Injuries—R Barnes
- 28 Derangements of Lumbar Spine and Pelvis—R B Young
- 29 Fractures and Dislocations of Shoulder—St J D Buxton

**Arthur Sims Commonwealth Travelling Professorship**—Mr Arthur Sims of Christchurch New Zealand has endowed a Commonwealth Travelling Professorship to be appointed each year from among the prominent physicians surgeons or scientific workers of Great Britain Australia or New Zealand or distinguished teachers from one of the other Dominions The Professor will be required to travel from the country where he or she is ordinarily resident to Great Britain or to Australia or to New Zealand or to any other Dominion of the British Commonwealth to promote the advancement of medical science either by lecturing teaching or engaging in research The first Professor—Sir Hugh Cairns K B E Nuffield Professor of Surgery in the University of Oxford is now in Australia

### INTERNATIONAL PHYSIOLOGICAL CONGRESS, 1947

The seventeenth International Congress of Physiology was held in Oxford in the late summer of 1947 The honorary degree of D Sc in the University of Oxford was conferred upon Dr Krogh Nobel Prize-winner, of the Zoophysiological Laboratory of Copenhagen who studied the physiology of respiration in both Olympic winners and Arctic explorers, Dr Szent-Gyorgi, Professor of Biochemistry in Szeged University, who was responsible for the discovery of vitamin C Dr Gasser Nobel Prize-man and Director of the Rockefeller Institute for Medical Research who used cathode ray oscillography in his study of the physiology of nerves Dr Houssay distinguished for his researches into the pituitary gland and Dr C H Best of Toronto head of the famous institute which couples his name with that of Frederick Banting of immortal memory **Birthday greetings to Sir Charles Sherrington, O M**—We would join with other Journals Societies, and Associations in offering our congratulations to Sir Charles Sherrington upon the occasion of his ninetieth birthday A new edition of his *Integrative Action of the Nervous System* which Professor John Fulton of Yale University recently ranked in importance with Harvey's *De Motu Cordis* was brought out in time for the Seventeenth International Congress of Physiology at Oxford The new twelve page foreword shows no falling away in the mental power vigour and integrity of the author In the words of the *Times* leader Few men of science have founded a new school of thought with so much friendliness, so little controversy—and so modestly To even fewer has it been given so happily to see for themselves through so many years the spreading triumph of their work

## SECOND INTERNATIONAL COURSE FOR THE EMERGENCIES OF MEDICINE AND SURGERY, 1947

The second international course organised by the Civil Hospitals of Lisbon, under the aegis of the Portuguese Ministry of the Interior, met in Lisbon and Oporto from October 1 to 15, 1947. Papers given by British representatives included

Acutely Prolapsed Intervertebral Disc—H A Brittain (Norwich)  
Tendon Injuries in the Hand—Professor R G Pulvertaft (Derby)  
Middle Facial Injuries and Burns—Sir Archibald McIndoe (London)  
Compound Fractures and Rehabilitation—H Osmond-Clarke (London)

## SOCIÉTÉ INTERNATIONALE DE CHIRURGIE ORTHOPÉDIQUE ET DE TRAUMATOLOGIE

Provisional Programme of Fourth Congress to be held in Amsterdam,  
September 13 to 18, 1948

*Monday, September 13 1948*

9 p m Reception by the President of the Congress—Dr Henry Meyerding

*Tuesday, September 14 1948*

9 30 a m Official opening of the Congress—Institute des Indes Amsterdam

1) Presidential Address

2) Official Addresses

10 30–12 30 a m Discussion on the Treatment of Arthritis Deformans of the Hip

2 30–5 p m Wilhelmina Hospital, Amsterdam—continuation of discussion

8 p m Reception

*Wednesday, September 15 1948*

9 30 a m –12 30 Wilhelmina Hospital Amsterdam—discussion on Closed Injuries of the Spine  
British rapporteur—Mr E A Nicoll

2 30 p m General Meeting of the Society

3 30–5 p m Continuance of discussion on Closed Injuries of the Spine

8 p m Reception

*Thursday, September 16 1948*

9 30 a m –12 30 Wilhelmina Hospital Amsterdam—Short Papers—Presentation of Cases

2 30–5 p m Short Papers and Presentation of Cases

8 p m Official Banquet

*Friday, September 17 1948*

9 30 a m Operating Sessions in the Amsterdam Hospitals

2 30 p m Excursion to the Dyke of the Zuiderzee

*Saturday, September 18 1948*

9 30 a m Visits to Dutch Orthopaedic Clinics at Nijmegen, Leiden, and Rotterdam

During the Congress excursions will be organised for the ladies by a special committee. Ladies are invited to the President's reception on Monday, September 13.

### Contemporary Journals

**Practitioner**—The March 1948 issue of the Practitioner will be devoted to "Orthopaedics in General Practice" and will include contributions on 'After-Treatment of Poliomyelitis' by Professor H J Seddon, 'Injuries of the Knee' by Roland Barnes, 'Dislocation of the Elbow' by J C Cherry, 'Tuberculosis of the Bones and Joints' by S A S Malkin, 'Amputations' by John Charnley. This Journal has made special efforts to promote the happy bond which has been strengthened during the recent war, between the English-speaking peoples. Dr Robert M Stecher has become a member of the Editorial Board. Most numbers include at least one contribution by an American writer.

**The Cord**—We offer every congratulation and good wish to "The Cord"—the new quarterly journal of the Paraplegic Branch of the British Legion. This publication was established in the autumn of 1947 by sixty patients at Stoke Mandeville Hospital, all suffering from paraplegia due to spinal injury. Every page of the first number breathes the spirit of independence and good humour. One column records "Famous Last Words"—

"I've never bothered much about this drinking business. I hate the taste of water anyway."

"Never mind about that air-ring. I can't feel there, so what's the point of it?"

"I've been dry for a week now."

"But I like going down steps forwards."

Again many congratulations—and if we can help the British Paraplegic Committee to maintain contact with the Paralysed Ex-Service Men's Associations of Australia, Canada, and the United States, we will do so.

**Medical Bookman and Historian**—This new monthly journal under the Editorship of Dr Croxon Deller and Dr W R Bett provides two cognate publications in one the Medical Bookman which includes signed reviews with a fullness unattainable in the average medical periodical and the Medical Historian a pioneer venture, which is the first periodical on the history of medicine in Britain The tradition of Osler the great internationalist will be followed and the editors hope to make the new publication as international in its scope as possible The publishers are Messrs Harvey & Blythe Limited 6 Hanover Square London W 1

### SCOTLAND

**Northern Region**—Base hospital Raigmore, Inverness Clinics held at Inverness, Fort William Nairn Forres Golspie Wick, Thurso the Isle of Skye and the Outer Hebrides It is hoped to establish orthopaedic physiotherapists in key positions in the near future

**North-East Region**—*Mr A M Rennie* has recently been appointed Lecturer in Orthopaedics in Aberdeen University and he serves all the hospitals voluntary municipal and E M S in the area Local authorities have arranged to send non-pulmonary tuberculous bone and joint cases for treatment in the orthopaedic section of the E M S Hospital at Stracathro

Orthopaedic surgery and particularly the local Cripples' Welfare Association, has sustained a severe blow in the death of *Mr F K Smith* Consulting Surgeon, Aberdeen Royal Infirmary As a member of the executive committee of the Association he rendered invaluable service and his sudden death has left his friends with a deep sense of personal loss

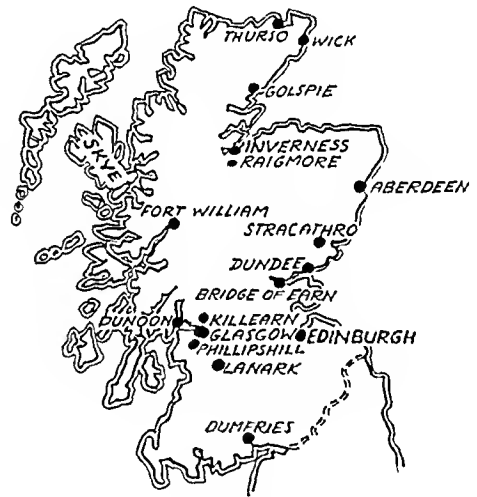
**Eastern Region**—Following the appointment of *Mr Smilie* to the Lectureship in Orthopaedic Surgery at the University of St Andrews and Surgeon-in Charge of the Eastern Region Orthopaedic Service the personnel and equipment of the Orthopaedic Hospital located at Larbert Stirlingshire, during the war was transferred to the E M S Hospital at Bridge of Earn Perthshire to serve as the Base Orthopaedic Hospital for the Region The initial capacity of 150 beds has already proved inadequate and it is hoped to increase the number by a further hundred in the near future Shortly after the establishment of the Base Orthopaedic Hospital the Residential Industrial Rehabilitation Centre was transferred from Gleneagles Perthshire to a site within the same grounds the capacity of the Centre is 160

The Clinics in Dundee Perth and Perthshire which were previously served from Princess Margaret Rose Hospital Edinburgh are being continued and expanded The only area of the Region not fully organised in relation to Statutory cases is Angus County where the present proposal is to set up Clinics in Forfar Brechin Montrose and Arbroath A Central Office to serve the Region has been established at the Royal Infirmary Dundee with the aid of a grant from the Lord Nuffield Trustees The staff consists of a Secretary and Social Service worker who are at present engaged in exploring the Region with a view to future developments

**West and South-West Regions**—Philipshull Hospital has been accepted as the regional long term hospital to serve the problem cases in Dumfries and Galloway Renfrewshire Lanarkshire Ayrshire and certain cases from Glasgow It is under the same board of management as the Victoria Infirmary which has an organised fracture service under unity of control Peripheral clinics are being established in the region more particularly in Lanarkshire and Renfrewshire Dumfries Royal Infirmary with its own segregated fracture service, has been established as a sub centre to serve Dumfries Kirkcudbrightshire and Wigtownshire The Royal Infirmary has peripheral clinics in the regions of Lanarkshire and Dumfriesshire, which it serves and the Western Infirmary—although it has not established peripheral clinics—has arranged for long-term cases to be treated at Killearn

Lanarkshire has an industrial rehabilitation scheme for miners—the only out patient centre of its kind in Great Britain and working under the auspices of the Miners' Welfare Commission Approximately one hundred patients attend daily for the final stages of rehabilitation before returning to work The average period of attendance is approximately six weeks

Recently a training school has been opened at Dunoon under the auspices of the Glasgow Cripples League where grossly handicapped girls are being trained in high grade needlework and specialised hand made clothing for children This centre was opened at the beginning of 1947 and arrangements have been made to market the products and to place the girls with selected firms or to provide for home supervision to market their products



**South-Eastern Region**—The Princess Margaret Rose Hospital (near Edinburgh) has secured the use of thirty extra beds, and has enlarged its Occupational Therapy Department and splint-making facilities by the use of E M S huts

## CANADA

### AWARD OF THE HONORARY GOLD MEDAL OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND TO WILLIAM EDWARD GALLIE



William Edward Gallie of Toronto awarded the most exclusive emblem of merit of the Royal College of Surgeons of England—the Honorary Gold Medal

The honorary medal, the most exclusive emblem of merit within the authority of award of the Royal College of Surgeons of England was conferred upon William Edward Gallie of Toronto in September 1947. This medal was instituted in 1802 and has been awarded on no more than twenty-two occasions in nearly one hundred and fifty years. The distinguished recipients who have qualified by their distinguished labours, researches, and discoveries, eminently conducive to the improvement of natural knowledge and the healing art include Erasmus Wilson in 1884, Lord Lister in 1897, Sir James Paget in 1897, Sir Henry Macking in 1929 and Sir Alexander Fleming in 1946. It is a gold medal with on the reverse Galen contemplating a human skeleton, and on the obverse the armorial bearings, crest, supporters and motto of the College.

Professor Gallie is a Fellow of the College of thirty years standing, a former Hunterian Professor, and recently Moynihan Lecturer when he chose as his subject "Recurring Dislocation of the Shoulder." He was President of the American College of Surgeons for five years and recently succeeded the late Elliot Cutler as President of the American Surgical Association. A few months ago on retirement from the Chair of Surgery in Toronto he was presented with a volume of clinical and scientific contributions written by his pupils, past and present.

In presenting him to the President of the College, Sir Max Page said: "Professor Gallie requires no

introduction to this College. He is a friend of many years to most of you. Many learned and surgical societies have honoured him on account of his scientific work and practical studies in regard to the grafting of bone and fascia. His practical application of these studies has made his name a household word for surgeons throughout the world. For twenty years or more as Professor of Surgery at Toronto he has put his stamp on the Canadian surgery of our generation. For five years he occupied the post of President of the American College of Surgeons which is great evidence of his excellent personality. We are delighted that our most distinguished Fellow should be honoured by the presentation of this Medal.

The President: Professor Gallie, I have the privilege of handing to you our most exclusive emblem of merit which has been awarded to you in the name of the College and by the authority of the Council.

Professor Gallie: I am so overwhelmed with emotion on this dramatic occasion that I find it quite impossible to express adequately my appreciation of the great honour you do to me. I am not so naïve as to think you do this solely because of the kind things Sir Max has said of me. You do it not only to honour me but to honour the American College of Surgeons and the surgeons of my own country. This Royal College of Surgeons has given me the most thrilling moments of my surgical career. That you should think that as a son of this ancient College I have upheld its traditions in my far country gives me the greatest satisfaction, and fills me with pleasure.



Honorary Medal of the Royal College of Surgeons of England

The President ' I have something to communicate and I would like to communicate it in public This cablegram reads Please convey to Professor W E Gallie when Gold Medal of College is conferred upon him congratulations from Toronto and Canada

**Professor Gallie at the Robert Jones Dining Club**—To celebrate the signal honour achieved by Professor Gallie and to pay homage to the greatness of his contribution to orthopaedic surgery the Robert Jones Dining Club—the oldest of its kind—arranged a special meeting and dinner when Gallie was the honoured guest of the twenty members of the Club He was toasted as the Robert Jones of the New World '

### CANADIAN ORTHOPAEDIC ASSOCIATION—ANNUAL MEETING, 1947

The third meeting of the Canadian Orthopaedic Association was held in Winnipeg on June 22 and 23, 1947

**Fusion of the ankle joint**—*J A Leo Walker* (Montreal Quebec) illustrated with a cinematograph film in colour the technique of fusing the ankle joint through a lateral approach removing the lower end of the fibula After denuding cartilage from the tibia and talus the raw fibular fragment was fixed as a graft by screws or stainless steel wire sutures

**Recurrent dislocation of the ankle joint**—*G F Pennal* (Toronto Ont) gave an audio-visual presentation illustrating 1) the relevant anatomy of the external lateral ligament and sites of complete rupture of the anterior and middle fasciculi at their proximal attachments 2) radiographs in full inversion including a post-mortem specimen to illustrate characteristic tilting of the talus within the mortise 3) technique of repair by Watson-Jones tenodesis using the peroneus brevis 4) post-operative results showing full range of dorsiflexion and plantar flexion movements stable joints permitting unrestricted activity and full correction of subluxation proved clinically and radiographically The importance of preventive treatment by early recognition of complete ligament avulsion was stressed The results of tenodesis were good

**Suction bucket prosthesis for above-knee amputations**—*R I Harris* (Toronto Ont) reported upon the programme in Canada for the development of the suction bucket prosthesis and the facilities arranged for its provision to veterans and civilians A survey of German scientific activities by the Allies after the occupation showed that they were using a prosthesis for above knee amputation which was held in place by suction developed within the bucket The German prosthesis was crude but the principle was valuable and such limbs had been used widely and successfully in Germany The same principle had been tried by the British in the early twenties but had been abandoned The advantages were 1) the possibility of discarding pelvic bands and shoulder harness 2) the lighter weight of the limb 3) the more perfect control by the patient especially of rotation movement 4) the fact that the patient felt the artificial limb to be part of him and not simply a suspended appliance The limb was being given extensive trial in Great Britain and the United States and in Canada where the programme was being directed by the Associate Committee on Artificial Limbs of the National Research Council Facilities were now available for its provision through the Department of Veterans Affairs and the availability of the prosthesis to civilians was in hand

**Giant cell tumour of the sacrum**—*L P Roy* (Quebec City Quebec) reported a patient aged twenty years who was admitted to the Hotel Dieu Hospital in November 1944 with pain in the sacrum impotence dysuria, and sciatic pain The left plantar and Achilles tendon reflexes were absent and there was muscle wasting and hypoaesthesia of the thigh Radiographic examination showed destruction of the sacrum which was proved on biopsy to be due to a typical benign giant cell tumour Radiotherapy was given (9000r) and in 1946 the tumour was curetted without grafting The region recalcified and in April 1947 the patient was working at home free from all symptoms

**High osteotomy for ununited femoral neck fractures**—*R G Townsend* (Calgary Alta) reviewed a short series of ununited femoral neck fractures treated by high femoral osteotomy some stabilised by means of a blade plate In 72.7 per cent a satisfactory result was secured with painless and stable weight-bearing function

**Observations on pinning fractured hips**—*Beattie Martin* (Regina Sask) reviewed seventy four cases treated in the previous two years most of the late age group the oldest aged ninety two years The Vol plate was used for intertrochanteric fractures and the Smith-Petersen nail or Godoy-Moreira screw for high fractures The screw gave excellent fixation but there was difficulty in engaging the large thread with hard bone near the acetabular surface Many failures with the Smith Petersen nail were due to insufficient engagement of the head Direct fluoroscopy was employed the radiologist lying under a table specially designed by Dr Perry of Grey Nuns Hospital Regina *Dr G H Ryan* (Winnipeg Man) described a technique of nailing through a stab wound under spinal or pentothal anaesthesia with fluoroscopic control The patient was sat in a chair the next day and allowed early ambulation with crutches

**Fusion of the wrist joint**—*A A Butler* (Montreal, Que.) reported fusion of the radio-carpal, inter-carpal and carpo-metacarpal joints of the wrist by means of a curved graft from the inner surface of the wing of the ilium. The graft was fan-shaped, and its natural curve permitted fixation of the wrist in the optimum position of ten degrees dorsiflexion, it was applied to a deep bed cut in the radius, carpus and second to fifth metacarpals. The operation was suitable for osteoarthritis, infective, tuberculous and

rheumatoid arthritis, infantile spastic and traumatic paralysis and congenital deformities. The advantages were the more rapid union than with tibial grafts, and the more certain union than with iliac chip grafts. Thirty patients, two with tuberculosis of the wrist, were successfully arthrodesed, one necessitating a second operation by reason of fracture of the graft.

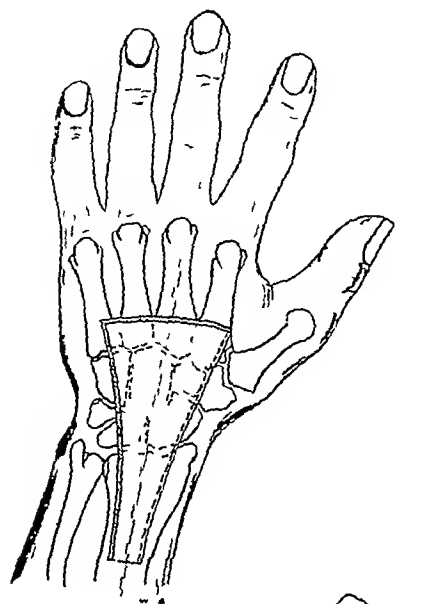
**Spondylitis due to pseudomonas pyocyaneus treated by streptomycin**—*Roger Ganevy* (Montreal). Bone and joint infections often complicate urinary sepsis, *pseudomonas aeruginosa* (*pyocyaneus*) being the usual causative organism. Fortunately it is sensitive to streptomycin as shown by dilution tests in vitro. This drug alone or combined with drainage checks local and general dissemination. A man aged fifty-six years developed destructive osteitis of the fourth lumbar vertebral body fifteen days after urinary infection due to transurethral resection of the prostate. Pain was the dominant symptom. It did not respond to penicillin, sulphadiazine or plaster immobilisation. Surgical drainage of a paravertebral abscess gave temporary relief, but infection spread up to the second and first lumbar vertebral bodies. *P. aeruginosa*, highly sensitive to streptomycin, was cultured from aspirated pus. The patient was given 3m units daily for ten days. Recovery was remarkably uneventful. The diseased area fused by intervertebral bridging of bone with sclerosis of the discs. The total disability from the onset of the complication lasted seven months.

**Late results in arthroplasty of the knee joint**—*J Ed Samson* (Montreal) reported results in forty three arthroplasties of the knee joint followed for more than five years. The cases included gonococcal arthritis 10,

traumatic arthritis 2, osteomyelitis 1, tuberculosis 1. The indication for arthroplasty was ankylosis of both knees, or of the hip and knee joint of the same side. A slightly modified Putti technique was used. No passive physiotherapy was used in the after-care. Muscles were re-educated by exercise against resistance. When necessary the neo arthritis was mobilised under anaesthesia. None complained of pain. There was only one unstable knee due to absorption of the medial condyle. All had full active extension, fifteen (30 per cent) had 90 degrees or more of flexion, fourteen (28 per cent) had from 60 to 40 degrees of flexion, and nine (18 per cent) had from 40 to 20 degrees of flexion. Re ankylosis occurred in twelve patients (24 per cent). Despite criticism Dr Edouard Samson believed firmly in the value of this operation which had given satisfaction.

**Bilateral congenital pseudarthrosis of the clavicles treated by costo-scapular fusion**—*J C Rossignol* (Ottawa) reported the case of a girl aged twenty-two years with congenital absence of the lateral half of the right clavicle, and congenital pseudarthrosis of the middle third of the left clavicle, who complained of excessive fatigue of both shoulders. There was no other deformity. Both scapulae were fused by operation to the thorax. The fourth rib was cut and its spinal end introduced into the scapula at its centre of rotation. A plaster spica was applied with the shoulders in 90 degrees abduction for four weeks. Seven years after operation re-examination showed three-quarters of the normal movement of the shoulder girdle on both sides with no functional complaint. The patient had resumed work as a typist and no longer complained of fatigue.

**Cup arthroplasty of the hip joint**—*J R Naden* (Vancouver B.C.) reported end-results in thirty six arthroplasties performed in the Orthopaedic Service of the Vancouver General Hospital. On the whole the end-results were gratifying in cases of osteoarthritis of the hip but very poor in rheumatoid arthritis. Twelve patients showed good or fairly good results, seven were fair. All four rheumatoid cases were poor. Five patients had since died. Nine were gainfully employed in work ranging from brick-laying and land



**GRAFT**

FROM INNER TABLE OF ILIUM  
WITH NATURAL CURVE AND CORTICAL  
SURFACE FOR DORSAL ASPECT AND  
CANCELOUS SURFACE FOR GRAFT BED

Arthrodesis of wrist, using fan-shaped curved graft from the inner table of the ilium



clearing to shorthand typing. Five were housewives doing light or full housekeeping. Except in the case of rheumatoid arthritis results were better than had been expected and arthroplasty was to be recommended in patients of the older age group as a procedure of less magnitude than arthrodesis offering good possibility of improvement.

**Early and late treatment of slipped upper femoral epiphysis**—*A. Samson and L. Jarry* (Montreal Que.) reported eight early cases treated by Leadbetter reduction with plaster immobilisation for three months using a Steinmann pin through the femoral condyles. In follow-up from nine months to three years the average shortening was  $\frac{1}{2}$  to 2 centimetres, there was normal function in six cases, slight limitation of flexion in one case and only one case of aseptic necrosis. Five late cases were treated by osteotomy with Steinmann pin or Blount blade plate fixation. Four results were excellent and one fair.

#### Stabilisation of the paralytic foot

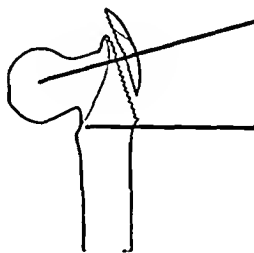
—*Urie Ikenette* (Montreal) reviewed 756 cases treated by tendon transfer, astraglectomy, arthrodesis and bone block. Tendon transfer used as the only procedure in twenty-four cases gave 67 per cent good results, fixed deformities and extensive paralysis were contra-indications when used as a complement to stabilisation or to assist dorsiflexion in ninety-three cases it gave 86 per cent good results. Astraglectomy in ninety-two cases resulted in stable mobile and painless feet in 76 per cent, poor results in 17 per cent and bad results in 7 per cent. The operation was indicated for calcaneocavus valgus deformity but not for pes planus. When used for equinovarus deformity there was a tendency



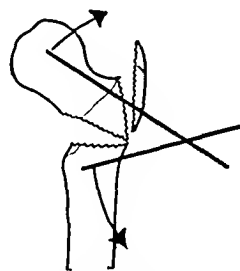
Coxa vara 90 degrees



Disinsertion of gluteal muscles by trochanteric section



Introduction of pin or screw



Correction of angulation towards 130 degrees by screws or pins

High femoral osteotomy for late slipped upper femoral epiphysis

to recurrent varus. *Panarthrodesis* was used in forty cases to stabilise in equinus either to compensate for shortening or to permit locking of a flail knee in hyperextension. 92 per cent of results were good. *Midline arthrodesis* was used in twenty-two cases of pes cavus with 87 per cent good results. Double arthrodesis was performed in fifty-seven cases. In the remaining 521 cases *triple arthrodesis* seemed the most logical means of stabilisation and correction, posterior bone block by the Nore-Josserand technique being used as an adjunct to limit plantar flexion in 319 cases and anterior bone block by the Putti technique to limit dorsiflexion in forty cases. The results were considered good in 80 per cent, poor in 13 per cent, bad in 7 per cent.

**Transplant of the trapezius for abductor paralysis of the shoulder**—*J. E. Bateman* (Toronto) discussed the problem of complete loss of shoulder abduction due to irreparable damage to the upper roots of the brachial plexus by traction injury. The lower roots were left undamaged so that the forearm and hand were good but were seriously impaired in usefulness by reason of the shoulder paralysis. The possibilities of nerve reconstruction, tendon transplantation and arthrodesis of the joint were assessed. A preliminary report on a new procedure was presented. The acromion process with fibres of the trapezius inserted into it, was transplanted to the upper end of the humerus. The post-operative result was illustrated by a coloured moving picture.

**Excision of the patella**—*H. M. Coleman* (Toronto) reviewed the merits of this operation which was first described in 1860. In a series of thirty-two cases the results were excellent in twenty-three, good in six, fair in two and poor in one. Normal function was to be expected if there was no abnormality in the knee joint and quadriceps mechanism other than in the patella itself. The patella and quadriceps tendons were sutured transversely with fascia lata, the suture line being 'bunched' or overlapped. Early mobilisation with intensive quadriceps redevelopment by resistance exercises were important. Patchy bone regeneration of the patella was often noted. A frequent complaint was aching in the knee after long sitting, relieved by straightening the joint. In four patients the patella was removed for recurrent dislocation or subluxation with chondromalacia; the capsule was then plicated on the inner side. The results were entirely satisfactory. In six other patients the patella was removed for advance chondromalacia. Two patellae fused to the femur were removed in association with quadricepsplasty and each patient



gained 80 degrees of active movement with a stable knee. All fractured patellae with displacement were removed except where a small fragment was detached from either pole, or from the margin in which case the fragment was removed.

**Traumatic lesions of the posterior tarsus** were discussed by *W B M Kinnon* (Winnipeg, Man.)

## AUSTRALIA

### AUSTRALIAN ORTHOPAEDIC ASSOCIATION—ANNUAL MEETING, 1947

The seventh Annual Meeting of the Australian Orthopaedic Association was held in Melbourne from June 3 to 7, 1947, under the presidency of Mr John Hoets. The meetings were held at St Vincent's Hospital Melbourne, the Children's Hospital, Melbourne and the Orthopaedic branch of the Children's Hospital at Frankston.

**Roll of spinal fusion in arthrogenic sciatica**—*Mr E F West* (Adelaide) reviewed fifty-two cases of sciatica treated by spinal fusion. In none was sciatic pain due to displacement of disc material. It was believed that apophyseal arthritis, mechanical in origin, and brought about by degeneration of the corresponding intervertebral disc with approximation of vertebral bodies, caused irritation, vascular congestion and swelling of the funicular segment of one or more nerve roots where they lay in proximity to the arthritic apophyseal joints. In thirteen (25 per cent) there was some degree of spondylolisthesis. The average age was forty-two years. Differentiation from sciatica due to herniation of the nucleus pulposus was not always easy. A period of observation and conservative treatment was advisable before considering operation. The fusion extended from the second lumbar vertebra to the sacrum. In forty-two cases two curved tibial grafts were reinforced with spongy bone. When iliac grafts were used alone, fusion often failed. The end-result study showed that 70 per cent of cases were good (relieved of all symptoms and capable of the same work as before onset of symptoms), 19 per cent were fair, and 11 per cent were unrelieved.

**Traumatic dislocation of the hip joint**—*Mr D W L Parker* (Hobart) referred to the increasing frequency of dislocation of the hip joint in road accidents and said that posterior dislocation was seven times as common as anterior. The immediate complications included fracture of the acetabular rim, fracture of the floor, fracture of the femoral shaft and injury to the sciatic nerve. Late aseptic necrosis was not uncommon and some degree of osteoarthritis was almost inevitable. In the various manipulations advocated for reduction, flexion of the knee was an essential feature. Three cases in which standard methods were impracticable were discussed in detail. Traction had been applied in the line of the limb. With the patient on a Hawley table a block of two pulleys was fixed to a Steinmann pin through the lower end of the tibia. The head was brought opposite the acetabulum with surprising ease and complete reduction was then achieved by external rotation of the limb. Similar pulley traction had been used successfully in 1823 by Sir Astley Cooper in reducing a five weeks' old dislocation of the hip. The method had a wide range of usefulness in complicated dislocations and those of long standing. *Mr Keon Cohen* (Melbourne) drew attention to the relative frequency with which reduction was prevented by bone fragments separated from the acetabular rim. *Mr Glisson* (Sydney) emphasised the need for long recumbency after hip dislocation in order to minimise the effects of avascular degeneration.

**Arthroplasty of the elbow**—*Mr A Cameron Armstrong* (Austintown, N.S.W.) gave details of a technique for arthroplasty used in soldiers with ankylosis of the elbow due to shell wounds. Through two longitudinal incisions, one on each side of the triceps tendon, the head and neck of the radius were removed and the humeral and ulnar elements of the ankylosed joint freed. Sufficient bone was removed from the humerus to make the surface flush with the flat area just above the condyles. The concave surface of the ulna was enlarged with a gouge, care being taken to preserve the insertions of brachialis and triceps. The sac of a hydrocele was drawn like a cap over the lower end of the humerus. Graduated movements were begun fourteen days after operation. Mr Armstrong was impressed with the stability of the new joint thus constructed, as compared with that of other techniques, 60 per cent of normal flexion, extension and rotation were regained without pain.

**Preventive orthopaedics**—*Dame Jean Macnamara* (Melbourne) discussed the prevention of knock-knee and everted feet, urged that the matter was of national importance (one group of splint makers in Melbourne alone having provided 440 children with knock-knee splints) and advocated a programme of: 1) standard footwear which did not force the child's foot into the everted position; 2) education of mothers to recognise the importance of distortion and excessive wear on the inner side of footwear; 3) education of mothers as to the consequences of children squatting on the floor in day-time and kneeling during sleep. Dame Jean also referred to investigations into the etiology of cerebral palsy in children, and stressed the importance of early recognition and suitable splintage to prevent deformities and secondary disabilities such as dislocation of the hip.

**Serum administration in infantile paralysis**—*Dame Jean Macnamara* traced the history of serum administration in the pre-paralytic stage, referred to the promising results in the 1930-31 epidemic in

Victoria and said that serum therapy had been discarded on insufficient evidence. Strains of virus were not identical in type, virulence, or power to induce immunity. Of nine epidemics in Victoria since 1925, eight had been of Type A and one (in 1937-38) of Type H. In the 1937 epidemic it was obvious from the second week that infection was spread by human contact. Serum therapy should be used with particular regard to the type administered. Further research was necessary, milk and dairy products were to be regarded with suspicion (milk consumption in Australia had increased in the last seven years from 165 to 206 million gallons annually) the research team should include field, veterinary, and laboratory workers.

**Treatment of congenital club foot—Mr G Keith Smith** (Sydney) said that after thirty years' experience he believed firmly that there was a primary muscular defect and that congenital club foot could not be explained by the simple effects of intra-uterine moulding. Treatment based on the supposition that the foot would become normal if held in an appropriate position long enough was obviously not a complete answer. The Denis Browne splint was valuable in that it gave a mobile foot with much less muscle wasting than in other methods, but there was difficulty in maintaining the heel in contact with the sole plate, he preferred the modified splint of Bell and Griee. The wedge cast method of Kite had stood the test of time and should be the standard method. He had performed Brockman's operation many times but had never derived much satisfaction from the results. Tenotomy of the tendo Achilles was seldom of value whether performed early or late. In relapsed or neglected cases aged five or six years manipulative correction was impossible, in thirty such cases he had removed a bone wedge from the neck of the talus and the calcaneo cuboid joint and secured a plantigrade foot in twenty-five. The chief causes of failure were neglect to continue fixations long enough and failure to insist on radiographic evidence of correction in antero-posterior as well as lateral projections.

**Pathology and treatment of tennis elbow—Mr J R Lahrz** (Brisbane) said that tennis elbow could be due to direct trauma as well as indirect muscular violence and that the muscle origins mainly concerned were the extensor carpi radialis brevis, the extensor digitorum communis and the supinator teres. The theory of an incomplete muscle tear was unsupported by histological evidence. He believed that the cause of pain was a localised synovial reaction. The acute stage often passed to chronic synovial inflammation with secondary involvement of capsule, muscles and rarely periosteum. In the acute stage plaster fixation was advisable with the elbow flexed and wrist dorsiflexed. Manipulation was worth trying in chronic cases but operation offered an almost certain cure. The origins of the extensor carpi radialis brevis and the finger extensors should be divided obliquely and the radio-capitular joint explored for thickened synovial fringes.

**Anterior and posterior marginal fractures of the distal end of the tibia—Mr A M Hill** (Perth) said that anterior marginal fracture with forward subluxation of the ankle joint was often an isolated injury, reduction of the subluxation was easy but accurate replacement of the marginal fragment often called for open operation and fixation with a vitallium screw. Posterior marginal fractures were usually associated with other fractures, if after manipulation a fragment including one-third or more of the articular surface remained displaced operative reduction and screw fixation was advisable. Strong traction from a Kirschner wire through the os calcis facilitated operative replacement through an incision along the lateral border of the tendo Achilles. With anterior or posterior marginal fractures persistent distortion of the tibial articular surface called for early rather than late arthrodesis of the ankle joint.

## NEW ZEALAND

### POLIOMYELITIS IN NORTH ISLAND

On December 1, 1947, all schools in the North Island of New Zealand were closed and all children's gatherings cancelled by reason of a threatened epidemic of poliomyelitis. Seventeen positive and eight suspected cases were reported in Auckland and two positive and three suspected cases in the Taranaki district. The last three major epidemics of poliomyelitis in New Zealand were in 1916, 1925 and 1936.

A memorandum circulated to all medical practitioners by the Department of Health after consultation with the New Zealand Branch of the British Medical Association, the Royal Australasian College of Physicians and the Royal Australasian College of Surgeons recommends that: 1) the use of serum even in the pre-paralytic stage has no influence on the extent or severity of paralysis; 2) paralysed muscles should be given complete physiological rest; 3) movement should be deferred for two or three weeks; 4) infected patients and contacts should be isolated for two weeks from the onset; 5) all children with fever should be isolated in bed pending diagnosis; 6) nose, throat and dental operations should be postponed; 7) physical strain in children should be minimised; 8) bathing in pools and ponds should be avoided and milk and food protected from fly contamination. On the merits of the Kenny treatment the report quotes the American Medical Association findings that such treatment involves an unnecessary waste of man-power and hospital beds and that there is no evidence to show that it controls pain or prevents paralysis. The report concludes that orthopaedic surgeons in the main centres are available for consultation and advice.

### POSTGRADUATE COURSE IN ORTHOPAEDICS

The postgraduate committee of the Wellington Hospital will be holding a four day postgraduate course on Orthopaedics and related subjects in March 1948

### VISIT OF DR E CARLSON OF NEW YORK

Dr E Carlson of New York will be visiting New Zealand in March 1948 at the invitation of the New Zealand Government in collaboration with the New Zealand Crippled Children Society. During his visit he will address the Divisions of the N Z Branch of the British Medical Association on the subject of Cerebral Palsy

### HUNTERIAN LECTURE BY MR MURRAY FALCONER

**Intervertebral disc surgery**—In a Hunterian Lecture at the Royal College of Surgeons of England delivered in London on October 17, Mr Murray Falconer analysed the first hundred consecutive operations performed in the Neurosurgical Unit at Otago. Of seventy-seven patients with severe sciatica one or more prolapsed discs were found in every one of twenty-three patients with low back pain twenty-two showed definite disc lesions. The four types of lesion were 1) protrusion covered by a thinned annulus, 2) pedunculated extrusion through the annulus 3) intermittent prolapse or concealed disc lesion 4) scarred and narrowed disc with osteophytic outgrowths. Mr Falconer believed that the interlaminar approach was inadequate, laminectomy of the fifth and part of the fourth neural arch was advisable. Twenty-seven patients had a double lesion at the fourth and fifth spaces. Curettage to expose bare bone should be done from both sides of the theca whenever prolapse approximated the midline. Spinal fusion was unnecessary and gave a less smooth convalescence. In earlier cases the orthopaedic surgeons fused alternate cases as control but this was abandoned because grafts often failed to fuse to the sacrum, or actually broke. Hypertrophy of the ligamenta flava was a secondary thickening and was never seen without disc protrusion. Secondary operations for recurrent symptoms were necessary in fourteen cases. A 100 per cent follow-up showed good results in 60 to 75 per cent, fair in 15 to 25 per cent, and poor in 5 to 10 per cent—results very comparable to those of internal derangement of the knee joint due to cartilage lesions

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### DISASTROUS FIRE AT ROBERT JONES AND AGNES HUNT ORTHOPAEDIC HOSPITAL

Within a few days of publication date we learn with deep regret of the disaster which occurred on Tuesday January 27 at the Robert Jones and Agnes Hunt Orthopaedic Hospital. In the early hours of the morning a devastating and rapidly developing fire swept through the main building, and reduced the open-air wards to smouldering ashes.

Six hundred patients, most of them immobilised in frames, splints, and plaster, were rescued without a single fatality or injury. While huge flames lit the sky, nurses and sisters pushed the beds and trolleys from the burning wards to positions of safety. In a deluge of pouring rain, such protection as was possible was afforded by mackintoshes and waterproof sheets. In due course all the six hundred men, women, and children were pushed by hand along the main road to emergency quarters in the Derwen Cripples' Training College, one mile away, and to Parkhall Military Camp.

Every one of the newly built wards was burned out. Only the old buildings and the concrete emergency wards remain. It is with pride and satisfaction that we record restoration of the routine of the hospital within five days. Patients are back once more, routine duties are re-established, operations are continuing, the functions of the greatest orthopaedic hospital in this country are being maintained.

# Book Reviews

**STUDIES OF THE RENAL CIRCULATION** By Josep TRUETA M D, Hon D Sc (Oxon), Alfred E. BARCLAY, O B I D M I R C P, F F R I A C R, Kenneth J. FRANKLIN, D M, F R C P, Peter M. DANIEL, M A, M B, Marjorie M. L. PRITCHARD, M A, from the Nuffield Institute for Medical Research 9 $\frac{1}{2}$  x 7 $\frac{1}{2}$  in Pp, vi + 187 with 83 figures Index 1947 Oxford Blackwell Scientific Publications Ltd Price 25/-

This book tells the story of one of the most remarkable researches in recent years. During the early days of the second world war clinicians working in cities subject to bombardment became increasingly disturbed by what is now known as the crush syndrome many patients died from renal failure after having had one or more limbs crushed for several hours under fallen masonry or heavy beams. A number of theories were advanced to account for this syndrome none of them altogether satisfactory.

In 1942 Barnes and Trueta found that in rabbits persistent spasm of the main arteries of a limb could be caused by the prolonged application of a tourniquet to the thigh. The spasm extended well above the site of compression and was even found to involve the main artery of the contralateral limb. It subsequently occurred to Trueta that this intense vascular spasm might extend high enough to involve the renal vessels and so cause the damage to the kidney that had been found in cases of crush syndrome.

In September 1945 when the main rush of war work was over a more elaborate investigation was undertaken. A large series of experiments was carried out by Trueta and Franklin contrast radiography being undertaken by Barclay and his assistant Marjorie Pritchard. A number of techniques was employed cineradiography in particular was invaluable for demonstrating the time cycle of changes in the renal circulation. At first the findings were very puzzling but in due course it emerged that there was not merely a diminution in the arterial flow through the kidney as had been suspected but a short circuit of blood within the kidney itself the circulating blood reached the renal vein unduly early without passing through the cortex. The next stage of the work was therefore a comprehensive investigation of the intrarenal vascular pattern, and here Dr Daniel's aid was invoked. He carried out a series of elegant injections of kidneys and aided by the observations of earlier workers showed that the anatomical basis of the short circuit was the vasa recta which pass into the medulla from the juxtamedullary glomeruli. These vessels are of large size and blood passing through them reaches the venous system without traversing a capillary network. The proof of the existence of a vascular by pass was therefore complete.

The course taken by the blood in its passage through the kidney does not show that degree of constancy that has commonly been imagined. In fact the kidney has two potential circulations, a greater and a lesser and in extreme conditions the blood may pass almost exclusively through one or other of two pathways or in less abnormal circumstances to a varying degree through both. The vessels making up the pathway of the greater circulation are those associated with the cortical glomeruli the channels of the lesser circulation are those associated with the juxtamedullary glomeruli.

How is this double circulation controlled? Further experiments showed that the shunt to the lesser circulation was produced by stimulation of the sympathetic supply to the kidney and that this was the mechanism involved when the lower limb was injured. The kidney damage was due to cortical ischaemia.

At this stage it became apparent that these findings opened up a far more extensive field of investigation than was originally envisaged. Ever since Bright's day the part played by the kidney has come to be recognised more and more as an important factor in the etiology of hypertension. It is now clear that organic renal disease precedes the onset of hypertension in a considerable number of cases, the Oxford work has an obvious connection with the investigations of Goldblatt and his colleagues.

It is not possible in a short review to trace all the steps by which Trueta and his co-workers arrived at their conclusions. Their book charmingly written and superbly illustrated must be read by those who wish fully to appreciate the significance of their achievements. The lesson to be learned from this work is that enlightened clinical observation may suggest experiments that can not only provide the explanation for the clinical phenomenon but will if followed with sufficient tenacity and imagination lead into other and perhaps more important fields of inquiry.—H. J. SEDDON

**BONE AND BONES** By Joseph P. WEINMANN M D and Henry SICHER M D 9 $\frac{1}{2}$  x 6 $\frac{1}{2}$  in Pp 464 with 289 figures Index 1947 London Henry Kimpton Price 50/-

Bone is an intriguing substance. Its innocent appearance of solidity and inertia gives little indication of the surprises it holds in store. It looks so dead that it is easy to treat it as if it really were dead as if it were no more than a block of marble carved with delicate artistry to fit the structures around it and give them support yet it is so very alive and forever busy shaping itself in adaptation to constantly changing demands. It is a living tissue albeit a highly specialised one and a component of a vastly complex organism so closely integrated that the smallest change in any single part is reflected in each other part. Bone is no more specialised than many other structures and like them it has its own ways of

reacting to changes in environment and its own diseases. And it is even kinder than other tissues in its response to injury since it has the unique property of healing without leaving so much as a scar. Surgeons engaged in problems of carpentering and engineering may forget the true nature of bone and fail to give due attention to its physiology and pathology. Here is a book no one of us can afford to neglect. A pathologist and an anatomist have co-operated to show us what bone is, how it grows, and how it behaves in health and disease. They clear away much dead wood from the tangled undergrowth of conventional teaching and make a clean start with proper emphasis on the confusion resulting from the dual meaning of the word bone—bone as a structure and bone as a tissue. The tibias are bones and are made of bone.

The book is notable for clarity of thought and expression. The development of bone is followed through all its stages and the diseases and deformities of both bone and bones are classified and explained in such a way as to correlate the clinical with the biological features. It is equally lucid whether discussing developmental deformities, adaptational deformities, the influence of endocrines and vitamins, tumours, the healing of fractures or inflammation. The authors freely admit they make use of working hypotheses to provide a logical sequence when existing data are uncertain or insufficient. This practice has many advantages but it is not always made clear when it is being followed, and a reader not familiar with current research might be misled by the authoritative presentation. For example, osteoblasts and osteoclasts are accepted without comment as makers and destroyers of bone although this is by no means certain and some leading bone pathologists consider both to be destructive agents. But this is a minor defect in an outstanding work, and anyone who makes himself master of its content must be the better surgeon for doing so.—PHILIP WILES

**BRITISH SURGICAL PRACTICE** Edited by Sir Ernest Rock CARLING, Consulting Surgeon, Westminster Hospital, and J. Paterson Ross Surgeon and Director of Surgical Clinical Unit, St Bartholomew's Hospital. Professor of Surgery, London University. In eight volumes. Volume I,  $9\frac{1}{2} \times 6\frac{1}{2}$  in. Pp. xix+486 with 228 figures and 2 plates. Index. 1947. London. Butterworth & Co., Ltd. Price £3 or £25 for set of eight volumes including general index.

This volume is the first of eight which are to form a surgical companion to the British Encyclopaedia of Medical Practice. Volume I comprises the subjects 'abdominal emergencies' to 'arteries'. One is reminded of the wide range of subjects having some interest for the orthopaedic surgeon by the titles abscess, actinomycosis, adiposity, amyloid infiltration, anaesthesia, angioma, anxiety states, arteries, asepsis, antiseptics and the autonomic nervous system. The subjects in this volume with an immediate orthopaedic concern are after-care, amputation, arthritis, artificial limbs, and asymmetry. It is an encouraging sign of the times that the subject of 'after-care' comprises not only an introduction by so active a restorer as Dr F. S. Cooksey, but monographs on post-operative care, the place of massage, remedial and occupational therapy and rehabilitation and the phase of return home—the last full of wisdom, by a physician. The monograph on amputations is confined to the major ones. It comes from the clear logical mind and ready pen of Mr George Perkins, and it expresses the pre-war Roehampton faith superlatively well. The devotees of that faith pursue a straight and narrow path. There is nothing in this monograph to suggest that the vast opportunities sadly provided by another war have led them to stray from their well-worn track but possibly this article exaggerates their constancy. By alphabetical good fortune the monograph on artificial limbs appears in the same volume. Dr Kelham has wisely refrained from mechanical details and has concentrated on the preparation of the patient and his stump for the fitting of the limb and on his training in the use of this, so that this article is a valuable supplement to those specifically on after-care. One suspects that pylons would receive little favour but for the cruel and uneconomic delay which still characterises the supply and readjustment of artificial limbs. Mr Norman Capener has written the monograph on surgical considerations in arthritis which is practically confined to osteo-arthritis and rheumatoid arthritis. He has our sympathy in tackling this very difficult subject. Cup arthroplasty of the hip is mentioned to the exclusion of Batchelor's procedure for a similar purpose. A monograph on the large subject of asymmetry is too condensed to be of much practical value.

The volume is extremely well produced in every way. It is not meant primarily for the undergraduate student or for the expert, but caters especially for the many surgeons whose life work is remote from libraries and centres of teaching and research. The first volume gives good promise that this end will be achieved.—H. JACKSON BURROWS

**DIE SKELETTVARIETÄTEN DES FUSSES. IHRE KLINISCHE UND UNFALLMEDIZINISCHE BEDEUTUNG.** By Theo. MARTI, Spezialarzt für Chirurgie F.M.H.  $9 \times 6\frac{1}{2}$  in. Pp. 164, with 58 figures. 1947. Bern. Hans Huber. Fr. 14.20. Paper cover.

The literature of the twenty varieties of accessory tarsal ossicles in adults is reviewed with a bibliography and considered in the light of ninety-nine personal cases. Developmental synostoses are also

discussed. Some accessory ossicles are considered to be atavistic developmental anomalies, others are derived post-natally from mechanical irritation of tendons. The ossicles may be regarded as sites of diminished resistance which may lead to static troubles or to deformities of the soft tissues or of the foot as a whole. They are subject to injury—distasis, dislocation, fracture—and to inflammatory changes. They tend to be painful after minor injuries and to delay recovery. Under Swiss insurance law this gives them a special medico-legal importance beyond that of correct diagnosis.—H. JACKSON BURROWS

THE REHABILITATION OF THE INJURED (Vol. 2. REMEDIAL GYMNASTICS) By John H. C. COLSON, M.C.S.P., M.A.O.I., Rehabilitation Officer, Birmingham Accident Hospital and Rehabilitation Centre, Birmingham. 8½ x 5½ in. Pp. xii + 549 with 439 figures. Index. 1947. London: Cassell & Co. Ltd. Price 30/-

This is the second book of a series written by Mr Colson and published under the general heading 'Rehabilitation of the Injured'. The book is the first attempt to describe the principles and the technique of remedial gymnastics based upon Ling's system of Swedish educational gymnastics as applied to injuries of the locomotor system in all stages of recovery.

Rehabilitation of the injured begins with operative or manipulative treatment to be followed by a period of rest and physiotherapy. Then comes the stage when our patients must be encouraged, stimulated, inspired with the knowledge that full recovery depends upon their efforts alone. In the bad old days we spoke these words of encouragement and left our patients to fend for themselves. They found the going hard and in our after-care clinics we noted far too often that muscles we hoped would redevelop remained wasted, joints remained stiff and too many patients lost hope. Armchair advice by surgeons had failed. Our patients needed more than good advice; they needed the facilities to carry out our advice and they needed technicians highly skilled in muscle and joint re-education to help them on their way. Mr Colson's book shows how detailed and careful the technique of muscle redevelopment must be. His text and generous illustrations present the subject matter clearly. The simple line diagrams accompanying many of the admirable photographs help considerably in giving a clearer understanding of the text.

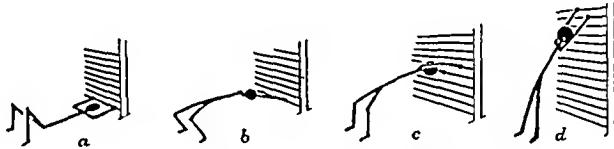


FIG 303

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FIG 304

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This book can be recommended not only as a text-book for rehabilitation staff, but as a book that should be in the library of all surgeons.

The chapter by Mr John M. Fitton, F.R.C.S., on 'The Relationship of Specific Remedial Exercises to Splints and Plaster Casts' is advisably included. But this chapter is far too short for the subject matter is important. Surgeons would do well to review their splint and plaster fixation methods (founded as most are on the principle of complete rest) in relation not only to specific but to general remedial exercises.—WILLIAM GISSANE

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# The Journal of Bone and Joint Surgery

## JOINT MEETING OF THE AMERICAN, BRITISH, AND CANADIAN ORTHOPAEDIC ASSOCIATIONS IN QUEBEC

Twenty years ago a joint meeting of the British and American Orthopaedic Associations was held in London. The occasion was a happy reunion of surgeons who worked together during the First World War under the leadership of Sir Robert Jones. Hey Groves, who was president of the British Orthopaedic Association, opened a discussion on the treatment of fractures of the neck of the femur. Fred Albee, president of the American Orthopaedic Association, displayed the skill of his carpentry in bone grafting. Royal Whitman used every device of charm and determination in resisting yet another demand for statistical evidence by which to support his claims for the abduction plaster spica. Smith-Petersen demonstrated a post-mortem specimen from which every member of the audience tried unsuccessfully to pull out the first three-flanged nail they had seen. Joel Goldthwait discussed postural deformities of the spine. Putti gave a polished presentation on the subject of congenital dislocation of the hip. Sir Arthur Keith showed specimens in the Museum of the Royal College of Surgeons of England. Steindler performed his muscle slide operation for pes cavus. Winnett Orr was developing the closed plaster treatment of bone infections, Bohler was advocating the Davis method of reducing fractures of the spine, Watson-Jones was drawing diagrams of a patient suspended between two tables.

After this interval of years it is easy to recognise the signs of progress which was imminent. Much water has since flowed beneath the bridges of the Thames. As A. P. Herbert would point out, the river is tidal and much of it has flowed back again. The Whitman plaster is no longer the treatment of choice for fractures of the femoral neck. Inlay bone grafting has been superseded by other methods of transplantation. Steindler's operation for pes cavus has been abandoned. Postural reduction of fractures of the spine is being discredited. The closed plaster treatment of bone infections is seldom indicated. Surgical pioneers whose work has been supplanted must remind themselves of the words of Priorov of Moscow: "It is poor tribute to a surgeon if in his lifetime he is not excelled by his own pupils."

That there has been striking and important progress cannot be denied, and it is perhaps surprising that no other joint meeting has been held in twenty years to celebrate the discovery in Britain of penicillin, and the development in the United States of safe methods of internal fixation—discoveries and developments which have revolutionised the treatment of bone infections and bone injuries. We recall the resolution of the American Orthopaedic Association, assembled in London, "expressing its appreciation for gracious hospitality and lavish expression of good fellowship. Closely bound to our British colleagues by every kind of human tie we express the hope that this delightful meeting may be the forerunner of other similar happy reunions."

Much of the credit for arranging the second joint meeting of the two Associations, now to be joined by the Canadian Orthopaedic Association, is due to Robert I. Harris of Toronto, who this year is president of the American Orthopaedic Association. So far as it is possible for him alone to assure success, it is assured by his American allegiance, Canadian nationality, and British instinct. So far as it is possible for the American Orthopaedic Association to assure success, it is assured by the fact that they have elected as president, vice-president, and chairman of the programme committee, three surgeons, none of whom is American—Robert Harris of Toronto, Alberto Inclan of Havana, Cuba, and John McDonald of Toronto.





Robert I. Harris of Toronto  
President of the American Orthopaedic Association

The American and Canadian Associations will be represented fully at this meeting, and if the decision had rested solely with the orthopaedic surgeons of this country the British Orthopaedic Association would have been represented no less fully. Over eighty fellows and members planned the journey to Quebec, many arranging to be accompanied by their wives. In due course they were informed that limited financial resources made it necessary for them to travel alone. Now it is learned that they themselves may not travel. No more than token representation is possible by a very limited number of members of the Association. Other members who we know, are resenting the decision forced upon us, must remind themselves of the words of Lord Keynes, uttered in the House of Lords as long ago as May 1944:

"We shall emerge from this war having won a more solid victory over our enemies, a more enduring friendship from our allies, and a deeper respect from the world, than at any time in our history. This is because we have sacrificed every precaution for the future with



S. Alan Malkin of Nottingham  
President of the British Orthopaedic  
Association



J. Edouard Samson of Montreal  
President of the Canadian Orthopaedic  
Association

a fanatical single-mindedness which has had few parallels. But the full price of this has still to be paid. In thus waging the war without counting the cost we—and we alone of the United Nations—have burdened ourselves with a weight of deferred indebtedness to other countries beneath which we shall stagger. We have already given to the common cause more than all we can afford."

It is true that we are staggering. It may be true that we have given more than all we can afford. But we shall survive. We shall indeed survive. On this occasion our representation is no more than a token, the greater part of which is made possible by the enduring friendship of our allies in the American continent whose offer of hospitality to thirteen young ambassadors of this country is characteristic of their generosity. But already we are laying plans for the next joint meeting in London, to include not only the Orthopaedic Associations of America, Canada, and Britain, but also the Orthopaedic Association of Australia, and, we trust, the Associations yet to be formed in Africa, New Zealand, India, Pakistan, Ceylon, and the British Colonies. In the words of Franklin Delano Roosevelt, whose memorial in Grosvenor Square was unveiled recently: "The only limit to our realisation of to-morrow will be our doubts of to-day. Let us move forward with strong and active faith."

EDITOR

## PARAPLEGIA IN CERVICAL SPINE INJURIES

Thoughtful and comprehensive studies of spinal injuries which were published by some of our surgical forerunners in the great text-books, monographs, and journals of the last century, established four possible methods of displacement—flexion, extension, lateral dislocation, and rotation. It was established that excessive flexion was the most usual means of cervical dislocation—excessive flexion combined at the same time with great pressure on the head, and twenty years ago this writer reviewed and brought up to date the broad principles underlying this mechanism (Proceedings of the Royal Society of Medicine, 1928, 625). At the same time special consideration was given to the most usual sites of injury. It seemed that fractures, or in the cervical region dislocations, occurred at the points of maximal curvature under stress. Since the spinal regions of greatest mobility were found to coincide with the greatest liability to injury, these were designated the “critical points of spinal injury”—a new proposition, because until 1928 it had been accepted that the spine broke at the junction of a mobile and a relatively immobile region. It would be wrong to assume that relative immobility of the thoracic spine had no effect whatever in determining the site of injury. What had been overlooked was that mobility of the adjoining portion did not in itself constitute the factor requisite for injury. There was some quality that needed taking into account in the mobility of the cervical spine and this, I thought, was its ability to produce a curve, the injury happening as it does with any material under bending-strain at the apex of the arc of curvature. This I still believe to be true, though I have been content to state the principle without elaborating it.

In the paper referred to, injury by extension was mentioned but its mechanism was not developed. That development has had to wait until to-day. In this issue of the Journal are two papers on extension injuries of the cervical spine which have a significance of conception that is their own. This does not lie in the fact that violent over-extension of the head can produce serious injury, but in the deductions drawn by the authors from their observations. Description of extension injuries can be found from the days of Malgaigne onwards, for example in 1853 Butcher reported an extension injury with rupture of the anterior common ligament. However, little serious thinking had been applied to the extension mechanism, except perhaps by Wagner and Stolper. These authors illustrated a good specimen of rupture of the anterior common ligament at the second-third cervical level which caused death from high spinal injury (*Die Verletzungen d. Wirbelsäule* 1898 Fig 91). Significantly, the specimen showed little or no displacement and some who described similar cases made the same observation, though none drew the inferences now made by Barnes, Taylor, and Blackwood. Wagner and Stolper, in an analysis of 205 cases collected from the Journals, found that 141 were flexion injuries, forty-nine were rotational injuries, and only fifteen were extension injuries, the high proportion of rotational injuries being accounted for, no doubt, by the inclusion of lesions of the atlas and axis. The proportion of extension injuries in the series reported in this issue by Barnes is much greater, though, as he says, there may be special reasons. But it could be true that they are more common than we have imagined because our minds have been occupied by a satisfactory explanation and we have failed to inquire closely enough into the possibility of the head being extended rather than flexed by the force of injury. It is difficult to know in what direction force has been applied to the head. When there is forward displacement the question scarcely arises. But when there is no displacement we are invited to believe that the injury has probably been by over-extension. For my part I am ready to accept this as correct for most cases. It is probably not absolutely true always. The point is not one to be laboured, for the difficulty of knowing the true facts of any injury in terms that would even begin to satisfy a physicist is too well known to ourselves. Our method of reasoning has usually to be deductive rather than inductive, but that does not necessarily mean that our conclusions are without value.

The special point about the contribution of Barnes is the significance he attaches to age, that extension injury is more common in those with relatively rigid necks and naturally therefore in the later decades of life. This is a first-rate piece of observation, supported by Taylor and Blackwood, for in such circumstances new mechanics must obviously apply.

The suggestion is made that in the majority of cases where there is cord injury up to a level, but with no evidence of displacement, the injury has usually been occasioned in this manner, by hyper-extension. With the exceptions drawn from very gross flexion joint ruptures it seems that they have gone far towards proving their point. If this conclusion is substantiated by other observers, and it probably will be, we have found an answer to a problem which has puzzled surgeon and neurologist alike for over a century. A virtue of this clarification will be the disposal of spinal concussion, a state of which some have written as if it could occur without anything coming into contact with the cord—an absurd notion indeed.

The part played by extrusion of disc tissue in causing damage of the cord has come to the forefront in recent years. So long ago as 1909 Thorburn wrote "more rarely the damage is done from the forcing back of intervertebral cartilage which forms a projecting shelf pressing against the cord" (Burghard's "System of Operative Surgery"). It would be untrue to suggest that Thorburn considered this to be a really significant feature of spinal trauma. He observed it, as had many others, at necropsy but regarded it as scarcely more than part of the disturbance of normal relationships produced by great violence. He was unable to illustrate it as an isolated event and proposed no particular treatment. In recent times the present writer has considered it a more serious feature (Proceedings of the Royal Society of Medicine, 1940, 651) and a discussion a few weeks ago in London is reported in detail in this number of the Journal. Beyond doubt further observations will put it in proper perspective.

The real problem of spinal injury is not altered materially by change of opinion as to what the agent of injury may be. If the cord has been badly damaged it is still fruitless to operate. If laminectomy alone had been the right step then older surgeons, who did this operation in cases of injury much more often than we do to-day, should have had far more success than, in fact, they had. But Barnes is quite right in pointing out that total extinction of cord function can occur without haemorrhage into the cord, a fact with which this writer has long been impressed (British Medical Journal, 1936, 1125). Unhappily, it does not follow that recovery is possible, for disruption of neural elements can occur without bleeding. The cord is not so vascular a structure that it cannot be damaged bluntly without haemorrhage.

The two papers published in this number have the virtue of that brevity and clarity with which new ideas are best expressed.

GEORGE JEFFERSON

#### TRAUMATIC URAEMIA

"More lives have been lost than ever were saved by the use of the tourniquet." Why does the prolonged application of a tourniquet cause death from uraemia? Is this complication the same as the uraemia of the crush syndrome? Is it safe to believe that in such cases life can be saved by amputation? What is the relationship between crush and tourniquet anuria, the anuria of mismatched blood transfusion and blackwater fever, and the uraemia of surgical shock?

In our last number we reviewed the work of Trueta, Barclay, Franklin, Daniel, and Pritchard who, in "one of the most remarkable researches in recent years," showed that there is a dual circulation in the kidney under sympathetic control which can be stimulated by arterial injury in the lower limb. The relationship between the anuria of cortical renal ischaemia due to lower limb injury, that of renal tubule blockage by the products of mismatched transfusion, and of renal anoxia due to fluid loss and shock, are not yet fully elucidated. In this number of the Journal we have invited from Dr Darmady a critical review on the subject of traumatic uraemia, and in a forthcoming number of the Journal we hope to publish a contribution on orthopaedic applications of the recent researches in Oxford.

EDITOR

# PARAPLEGIA IN CERVICAL SPINE INJURIES

ROLAND BARNES, GLASGOW, SCOTLAND

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The first recorded reference to paraplegia in cervical spine injuries is to be found in the Edwin Smith papyrus, written some four thousand years ago. The unknown author comments briefly upon the condition: "One having a crushed vertebra of his neck, he is unconscious of his two arms and two legs, and is speechless. An ailment not to be treated." Such pessimism was not without justification for in spite of notable contributions by Walton and Taylor, and more recently the introduction of caliper traction by Coleman, McKenzie, and Crutchfield, considerably more than half the patients with paraplegia die from the complications of spinal cord injury, and many survivors are left with varying degrees of paralysis.

One of the most puzzling features of injuries of the cervical spine is the lack of correlation between the degree of vertebral displacement and the severity of the spinal cord lesion. There are cases with no radiographic evidence of bone injury in which the cord is irretrievably damaged, others, with gross dislocation, may have no paraplegia. It is commonly believed that the spinal cord is damaged by the dislocated neural arches, and in the absence of radiographic evidence of bone injury it is assumed that spontaneous reduction of the dislocation has taken place. This view is not, however, in accord with experimental or post-mortem observations.

Radiographic study of specimens in which the dural sac has been filled with lipiodol shows quite clearly that the dislocated neural arches do not produce a degree of narrowing of the spinal canal which would compress the cord until there is locking of at least one articular process (Fig. 1). Once the articular processes are locked the dislocation is usually stable, and reduction cannot be secured without manipulation. Furthermore, examination of post-mortem material and observations at operation have convinced me that spinal cord injury can occur in the absence of any vertebral dislocation, and unless there is clear radiographic evidence of fracture of the articular processes which will permit spontaneous reduction of the dislocation we should look for an alternative explanation of the cord injury.

## TYPES OF CERVICAL INJURY

Damage of the cervical cord may be caused by flexion injuries and hyperextension injuries. The number of cases of each type of cervical injury in a series of twenty-two patients with paraplegia is shown in Table I.

TABLE I

<i>Flexion injuries—</i>	
Dislocation	8 cases
Crush fracture of vertebral body	4 "
Acute retropulsion of intervertebral disc	3 "
Total	15 "
<i>Hyperextension injuries—</i>	
Dislocation	1 "
Injury to arthritic spine	6 "
Total	7

Three types of flexion injury may be recognised: 1) anterior dislocation, 2) crush fracture of a vertebral body, 3) acute retropulsion of an intervertebral disc. There are two types of hyperextension injury: 1) posterior dislocation, 2) injury to an arthritic spine.



FIG 1

Experimental displacements of the cervical spine in which the dural sac has been filled with lipiodol. A shows the specimen in neutral position and C D E show degrees of flexion dislocation. B is a soft tissue radiograph of the spinal cord for comparison of size. In C there is subluxation of the articular processes. In D one articular process is locked. In E both articular processes are locked. The spinal cord is not compressed by the displaced neural arches until at least one articular process is locked.

It must be emphasised that these twenty-two cases were not an unselected group, for the reason that some were treated in a Spinal Injury Centre which tends to receive the more obscure types of injury. It is likely therefore that an unselected series would show a higher proportion of dislocations. The age incidence of the various groups is interesting (Fig 6). All flexion injuries, and the one dislocation in extension, occurred in patients under fifty years of age, no hyperextension injuries in arthritic spines were encountered in patients under

fifty-seven years of age. The mortality rate in all types was high except in the group of three patients with disc injury, all of whom survived.

### FLEXION INJURIES OF THE CERVICAL SPINE

**Cervical dislocations**—In dislocation of the cervical spine it is generally agreed that cord injury may be due to a combination of two factors: *a*) pressure on the dorsal surface of the cord by the dislocated neural arches, and *b*) often co-incident compression of the ventral surface of the cord by retropulsed disc material. Skeletal traction by means of a skull caliper is the treatment of choice. The dislocation can be reduced easily, without risk of further damage to the cord, and with better prospect of relieving the pressure of the disc than by other methods. The nine dislocations in this series presented no unusual features and it would be unprofitable to discuss them in further detail.

**Acute retropulsion of disc**—There were three cases of this type, all due to forcible flexion of the head on the trunk. In none was there radiographic evidence of bone injury but all the radiographs showed narrowing of one intervertebral disc.

*Case 1. W. T. aged 34 years*—Fell over the handlebars of his cycle on to the back of his head. He was examined within an hour of the accident and found to have incomplete paralysis and sensory loss in the lower limbs, trunk and upper limbs. Radiographic examination showed lipping of the anterior margin of the third and fourth cervical vertebrae and narrowing of the intervertebral disc (Fig 2). There was no bone injury. On the day after injury paralysis of the legs had increased and there was retention of urine. The Queckenstedt test showed complete spinal block, and myelography revealed an arrest of lipiodol opposite the damaged intervertebral disc (Fig 3). By the third day there was complete paralysis of both legs. Laminectomy was performed, and a large protrusion of the disc was observed between the third and fourth vertebrae. The cord was compressed between the disc and the laminae, and pulsation did not return to the cord until the third, fourth, and fifth laminae had been removed. There was steady recovery of motor power and sensation after operation, and two months later the patient was able to walk without support.

*Comment*—Radiographic evidence indicated that the disc was degenerated before the accident, and this no doubt predisposed to "massive" protrusion of disc substance into the spinal canal as the result of flexion injury.

In the other two cases, considerable recovery of paralysis occurred without operative treatment (Table II), and there is therefore no proof that the cord injury was caused by acute disc protrusion. Nevertheless the mechanism of injury, the narrowed intervertebral disc, and the absence of radiographic evidence of bone injury, make the diagnosis reasonably certain.

Similar cases have been reported by Brooke (1944) and Brown and Little (1939). Although the Queckenstedt test in Brooke's patient gave normal readings, post-mortem examination revealed a large protrusion of the disc which was causing severe compression of the cord.

*Treatment*—We have now to consider the treatment most likely to relieve pressure on the cord in acute disc protrusions. Providing that the disc is not degenerated before injury, caliper traction will restore the normal disc height, and it is possible that some at least of the disc substance may find its way back into the intervertebral space. Even if this does not happen traction should straighten out the knuckle pressing on the cord (Jefferson 1940). If paraplegia is incomplete, and the Queckenstedt test gives normal readings of cerebro-spinal fluid pressure, the cord is probably not under severe compression and preliminary trial of skull traction is justified. If there is no recovery of paraplegia within a few days of the application of skull traction, laminectomy should be considered even when the Queckenstedt test is negative. Fleiss and Ingham (1943) and Brooke (1944) have reported cases of cord compression by a herniated disc with normal manometric readings.



FIG 2



FIG 3

Case 1 W. T., aged 34 years. Flexion injury of the cervical spine with incomplete paraplegia. Fig 2 shows that the intervertebral disc between the third and fourth cervical vertebrae is narrowed but there is no bone injury. Myelography after injection of lipiodol into the lumbar theca (Fig 3) shows a complete block at the level of the herniated disc.



FIG 4



FIG 5

Case 4 A. G., aged 30 years. Fracture of cervical spine with residual paralysis of upper and lower limbs two years after injury. Fig 4 shows crush fracture of sixth cervical vertebra. Fig 5 shows the myelogram. There is a filling defect opposite the fractured vertebra.



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**Crush fracture of cervical vertebra**—Four patients sustained crush fractures of the cervical column without radiographic evidence of dislocation of the articular processes. These cases are summarised in Table III. Post-mortem examination was made in the two fatal cases (Cases 5 and 6). In both, the spinal cord was severely crushed but there was no dislocation of articular processes. In Case 5 there was a large protrusion of the disc into the spinal canal. The two patients who survived had initially incomplete paraplegia, and yet there was poor recovery of function during a period of two years after injury.

*Case 4*—*Male, aged 30 years*—Crush fracture of the sixth cervical vertebra, treated in a plaster jacket for three and a half months. He was admitted to the Spinal Injury Centre two years later with residual paralysis of both upper and lower limbs. Myelography showed a constant anterior filling defect which could hardly be explained by the residual spinal deformity, and was presumably due to disc protrusion (Figs 4 and 5).

The evidence of this case strongly supports the view of Cramer and McGowan (1944) that cord injury in simple crush fractures is due not to pressure of the fractured vertebral body, or to dislocation with spontaneous reduction, but to compression of the ventral surface of the cord by retropulsed disc material. The treatment of compression fracture of a cervical vertebra complicated by paraplegia should therefore be on similar lines to that of compression of the spinal cord by a retropulsed intervertebral disc.

#### HYPEREXTENSION INJURIES IN ARTHRITIC SPINES

I have been unable to find any reference to injuries of arthritic spines except in the paper by Crooks and Birkett (1944). Nevertheless these injuries are by no means uncommon. In the present series there were six cases of this type and they were responsible for all spinal cord injuries in patients over fifty years of age (Fig. 6). All six patients had arthritic changes

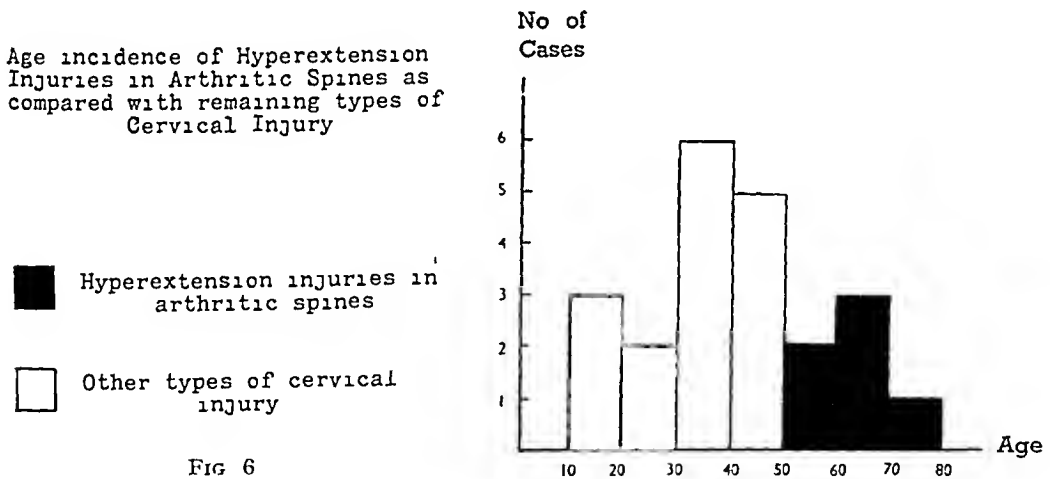


FIG 6

in the cervical spine of moderate or severe degree, and there was strikingly little radiographic evidence of recent vertebral injury. The injury proved fatal in five of the six patients although only one had complete paraplegia. Two cases serve to illustrate the features.

*Case 12*—*T. B. aged 63 years*—Fell a distance of ten feet on to his forehead, forcibly hyperextending the neck. There was complete motor paralysis and sensory loss below the fifth cervical cord segment. Radiographs showed marked osteoarthritic changes in the cervical spine with ossification of the anterior common ligament between the fourth, fifth and sixth vertebrae (Fig. 7). An osteophyte was avulsed from the lower anterior margin of the third cervical vertebrae; there was no other bone injury. Five hours after injury he was able to move the left leg and tactile sensation had returned to both lower limbs. Four days after injury the patient was able to move both legs and urine was passed voluntarily. The Queckenstedt test showed no spinal block. From the eighth day his condition deteriorated steadily and he died on the eleventh day after injury.



FIG 7



FIG 8

Case 12 T B aged 63 years Hyperextension injury of osteoarthritic spine with incomplete paraplegia Fig 7 shows an osteophyte avulsed from lower margin of C 3 The anterior common ligament is ossified between C 4, 5, and 6 Fig 8 shows the autopsy specimen, the anterior common ligament and intervertebral disc between C 3 and 4 are ruptured

Post-mortem examination revealed rupture of the anterior common ligament between the third and fourth cervical vertebrae The rupture extended through the intervertebral disc to the posterior common ligament which was intact (Fig 8) Abnormal hyperextension of the spine was possible at the level of injury but there was no dislocation of the articular processes The spinal cord had a normal appearance apart from slight constriction at the level of injury

*Comment*—The post-mortem findings prove beyond doubt that this was a hyperextension injury Ossification of the anterior common ligament in the lower cervical spine accounted for localisation of violence to the upper vertebrae, and the anterior common ligament ruptured immediately above the ossified region The cord injury was not severe, and a younger patient might have recovered

Case 9 T A aged 58 years—Fell from a glass roof on to his head There was complete motor paralysis pain and temperature sensation were impaired below the fourth cervical cord segment, other forms of sensation were normal Radiographs showed moderate arthritic changes in the cervical spine but no evidence of recent injury There was no change in the neurological findings until he died eighteen hours after injury

Post-mortem examination showed rupture of the anterior common ligament between the sixth and seventh cervical vertebrae (Fig 9) The intervertebral disc was avulsed from the body of the upper vertebra but the posterior common ligament was intact Abnormal hyperextension of the spine was possible at the level of injury the upper vertebra hinged on the lower with the articular processes acting as the fulcrum The joint capsule of the articular processes was intact on both sides The spinal cord had normal appearances apart from slight constriction opposite the sixth cervical vertebra no intramedullary haemorrhage was observed on section of the cord (Fig 10)

*Comment*—The post-mortem findings were very similar to those in Case 12, and proved beyond doubt that the injury was due to hyperextension violence Neurological examination indicated that the level of spinal cord injury was three to four segments higher than that of vertebral injury, and it is therefore unlikely that the paraplegia was due to direct contusion of the cord It is possible, however, that the cord was subjected to traction at the moment



FIG 9

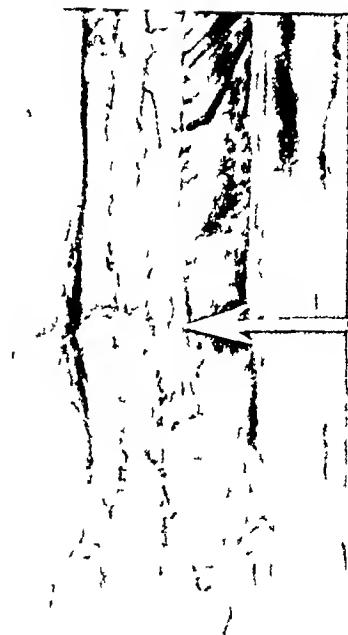


FIG 10

Case 9 T N aged 58 years. Hyperextension injury with incomplete paraplegia (Fig 9). The anterior common ligament between C 6 and 7 is ruptured and the disc is avulsed from the upper vertebra. Fig 10 shows slight constriction of the spinal cord at the level of vertebral injury.

of extreme hyperextension, and in these circumstances the upper level of the cord lesion might well be several segments higher than the vertebral injury.

No post-mortem examination was made in the other three fatal cases but the nature of accident, and the radiographic appearances, leave little room for doubt that they too were hyperextension injuries. A summary of the clinical and radiographic features of the six cases is given in Table IV.

TABLE IV  
HYPEREXTENSION INJURIES IN ARTHRITIC SPINES

Case	Age	Nature of injury	Radiographic appearances	Type of paraplegia	Result
8 J S	57	Fell downstairs on to face	Moderate osteoarthritis. Osteophyte avulsed from lower margin of C 6. No displacement.	Incomplete	Recovery apart from residual weakness in hands.
9 T N	58	Fell through glass roof	Moderate osteoarthritis. No fracture or dislocation.	Incomplete	Death second day.
10 M C	77	Knocked down by motor car	Advanced spondylitis. Vertebrae ankylosed below C 4. Fracture lower margin of C 3. Backward displacement of C 3 on 4 by 5 cm.	Incomplete	Death fourth day.
11 J McQ	67	Knocked down by car	Gross osteoarthritis. No fracture or dislocation.	Complete	Death one week after injury.
12 T B	63	Fell from ladder distance of ten feet on to head	Gross osteoarthritis. Fracture of osteophyte on lower anterior margin of C 3. No dislocation.	Incomplete	Death tenth day.
13 G B	61	Fell seven feet from scaffolding on to forehead	Gross osteoarthritis. No fracture. Widening of intervertebral space between C 4 and 5 anteriorly.	Incomplete	Death second day.

**Mechanism of injury**—Elderly patients are predisposed to hyperextension injury by two factors. With advancing years there is a tendency to kyphosis of the thoracic spine which

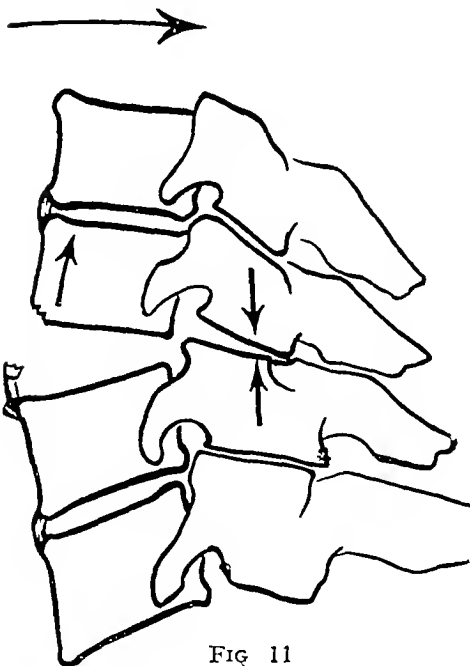


FIG 11

Mechanism of hyperextension injury of cervical spine. The anterior common ligament is torn or avulsed with a bone fragment. There is no dislocation of articular processes.

is usually compensated by cervical lordosis (extension deformity of the neck—Fig 12). This is a relatively fixed position, and any increase in the degree of extension is liable to cause strain or injury (Brown and Kuhns 1942). The risk of injury by hyperextension violence is greater when mobility of the spine is impaired by arthritic changes in joints and ligaments. In the event of a fall, the neck cannot be flexed in the normal defensive manner, so that when the head strikes the ground powerful angulation strain in extension is applied to the cervical region. The brunt of this violence falls on the anterior common ligament; it may rupture, or a small flake of bone may be avulsed from the lower anterior margin of the upper vertebra (Fig 11). The tear extends backwards through the intervertebral disc, or the disc itself may be torn from the vertebra above. There is no tendency for the disc to herniate into the spinal canal as in the case of flexion injuries. Once the disc has ruptured there is little resistance to further hyperextension, and considerable separation of the vertebral bodies can occur without rupture of the lax posterior

common ligament or the zygapophyseal joint capsules. Immediately the striking force is removed normal alignment of the vertebrae is restored by spasm of the neck muscles and for this reason the radiographic appearances may be deceptive (Case 9).

**Nature of the spinal cord injury**—I have been unable to find a completely satisfactory explanation of the spinal cord lesion in these hyperextension injuries. Unlike flexion injuries there is neither gross dislocation of the vertebrae, nor retropulsion of the intervertebral disc. The cord damage is not usually severe, for the paraplegia was incomplete in five of the six patients. Two possible explanations of the spinal cord injury have been considered: 1) that it may be caused by "spinal concussion" as the result of minor displacement of a vertebral body, or 2) that it may be due to traction injury at the moment of extreme hyperextension.



FIG 12

Tracing of radiograph of extension deformity of cervical spine compensatory to severe thoracic kyphosis. The angle between pedicles and body is more acute than in a normal spine and the spinal canal is therefore narrowed.

When there is extension deformity of the neck compensating for thoracic kyphosis the angle between the vertebral bodies and the pedicles is decreased (Fig 12), and consequently the spinal canal is narrowed. Moreover, in hypertrophic arthritis, osteophytes may project from the posterior margins of the vertebral bodies into the spinal canal and still further reduce the margin of safety. In these circumstances it is possible that minor displacements of the vertebrae may be sufficient to concuss the spinal cord.

We have also observed that when the disc is ruptured considerable separation of vertebral bodies is possible and it is tempting to postulate that there may be traction injury of the cord. The fact that in some patients the neurological level of cord injury was several segments higher than the vertebral injury gave support to this view.



FIG 13



FIG 14

Steel markers have been placed in the spinal cord through the intervertebral disc between the third and fourth and fifth and sixth vertebrae (Fig 13). The anterior common ligament and intervertebral disc between the fourth and fifth vertebrae have been divided and the neck hyperextended (Fig 14). There is no increase in the distance between the markers and therefore no evidence that traction force has been applied to the spinal cord.

Experiments were performed on cadavers to test the accuracy of this hypothesis. Hollow needles were inserted through the intervertebral discs immediately above and below the one which was to be divided, and were pushed on into the spinal cord. After checking the position of the needles by radiography a steel marker was introduced through the lumen of each needle into the spinal cord and the needles were removed. Further X-ray films were taken and the distance between the markers measured. The anterior common ligament and intervertebral disc between the two markers was divided. With wedges placed between the spinous processes above and below the level of section, in order to simulate the rigidity of an arthritic spine, the neck was forcibly hyperextended until there was a considerable gap between the vertebrae. Further radiographs were taken in this position and the distance between the markers again measured. Finally the spinal cord was removed and the position of the markers rechecked by radiography. These tests failed to demonstrate any separation of the markers, and the theory that paraplegia may be due to traction injury of the cord is unsupported. It must be admitted, however, that the experiments were crude, and certainly did not reproduce accurately the conditions of the living subject, so that it would be unwise to dismiss finally the possibility of mild traction lesions which stop short of neural disruption.

**Treatment**—There is no indication for the use of caliper traction in hyperextension injury of an arthritic cervical spine. The intervertebral disc is not displaced backwards into the spinal canal, and any vertebral displacement that there may be is corrected easily by moderate flexion of the neck. It is not necessary to use external splintage for it cannot assist restoration of cord function, and elderly patients are so intolerant of plaster jackets or collars that their application often hastens the fatal termination.

Since becoming aware of the true nature of these injuries I have been content to do no more than use a small pillow to keep the neck slightly flexed, and to arrange the usual nursing care of a paraplegic patient. It cannot be claimed that the results are any improvement on more ambitious methods, but at least it has the merit of making more comfortable the few remaining hours or days of the patient's life.

### SUMMARY

Twenty-two cases of paraplegia complicating injury of the cervical column have been reviewed. The vertebral injury may be due to flexion or hyperextension violence. *Flexion injury*—There are three types of flexion injury: 1) dislocation, 2) compression fracture of a vertebral body, 3) acute retropulsion of an intervertebral disc. Evidence is presented in support of the view that disc protrusion is the cause of the cord lesion when there is no radiographic evidence of bone injury, and in some cases at least when there is a compression fracture. Treatment is discussed and the indications for caliper traction and laminectomy are presented.

*Hyperextension injury*—There are two types of hyperextension injury: 1) dislocation, 2) injury to arthritic spines. Hyperextension injury of an arthritic spine is the usual cause of paraplegia in patients over fifty years of age. The mechanism of hyperextension injury is described. The possible causes of spinal cord injury, and its treatment, are discussed.

The author wishes to thank Mr Nichols for the clinical details of Case 1 which was under his care in the Neurosurgical Service at Killearn Hospital, and Mr J. Tulloch Brown for assistance with the experimental observations.

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# PARAPLEGIA IN HYPEREXTENSION CERVICAL INJURIES WITH NORMAL RADIOGRAPHIC APPEARANCES

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This communication deals solely with a group of cases, hitherto rather obscure, in which damage to the cervical part of the spinal cord occurs without radiographic evidence of vertebral injury or displacement. Two alternative explanations of such injury have been postulated. The first is that the spinal cord pressure is due to acute massive prolapse of an intervertebral disc but our limited experience of this lesion suggests that as a rule this is recognisable on radiographic examination by narrowing of the intervertebral space. The second explanation is that paraplegia is due to hyperflexion dislocation which undergoes spontaneous reduction, but it is doubtful whether this occurs at all, because forward flexion or dislocation of the cervical spine which is sufficient to damage the cord would necessarily be associated with locking of the articular facets, or crush fracture of a vertebra, or both. Neither of these lesions undergoes spontaneous reduction, and moreover both are demonstrable by radiographic examination. We suggest that the usual mechanism of these injuries, in which radiographic examination reveals no significant displacement, is forced hyperextension.

**Case Report**—A miner aged thirty three years was admitted to hospital twelve hours after injury sustained by falling downstairs on his face. There was immediate and complete paraplegia to the level of the seventh cervical segment of the cord. Radiographs showed an oblique crack in the body of the second thoracic vertebra without displacement, which obviously was not related directly to the cord damage and a crack in the left upper articular process of the seventh cervical vertebra, also without displacement. There was no narrowing of disc spaces. Lumbar puncture showed that the cerebrospinal fluid was clear and that there was free conduction of pressure throughout the theca. Pantopaque was introduced in order to determine whether or not there was compression at the site of the cord lesion. With the patient in both prone and supine positions the oil passed freely to the foramen magnum and it was thus clear that whatever may have caused the original cord damage it was no longer exerting pressure. On the third day the patient showed signs of ascending cord oedema with hyperthermia, tachypnoea and failure of the peripheral circulation. In this state he died. Autopsy revealed that the anterior longitudinal ligament was ruptured between the sixth and seventh cervical vertebrae; the column had been torn through by detachment of the intervertebral disc from the lower surface of the sixth vertebral body. The upper segment of the column carrying with it the intact posterior longitudinal ligament, could be displaced backwards on the lower segment with great ease, the disc remaining attached to the upper surface of the seventh vertebra and the posterior longitudinal ligament being lifted from its posterior surface (Fig. 1). At this point there was a sharply localised contusion of the cord, the principal haemorrhage being situated posteriorly, exactly opposite the sharp upper margin of the seventh cervical lamina. The displacement could be replaced easily and it tended to remain in the replaced position (Fig. 2). There is little doubt that this occurred during life, thus accounting for the normal radiographic appearances. It accounts also for the peculiarly localised cord injury which represents a sharp nip, without stretching and is in contrast with the more diffuse contusions which are encountered in flexion injuries and in which the cord may be both stretched and compressed.

In this case the nature of the injury admits of no doubt. The mechanism is substantiated equally well in the case of a sixty-year old man who fell from a haystack and had signs of a complete transverse lesion of the cord at the fifth cervical level. Radiographs were negative, and there was no subarachnoid block. There was, however, persistent increase in the protein content of the cerebrospinal fluid obtained by lumbar puncture, and after much thought it was decided to explore by laminectomy in order to determine whether or not there was any compressing factor. Exploration was negative, and in particular



there was no intervertebral disc protrusion. Lateral radiographs of this case taken six months after injury showed a calcified shadow at the anterior margin of the fourth-fifth cervical interspace, which was interpreted as heterotopic calcification in the haematoma associated with rupture of the anterior longitudinal ligament.

In many other cases with cord damage and no vertebral displacement it has been suspected that the injuries may have been of this type, but in these instances no evidence has been available from autopsy or operation.

**Discussion**—It is suggested that hyperextension is not only *one* of the mechanisms of injury in the type of case under discussion, but that it is the *usual* mechanism. This has not been recognised hitherto, no doubt because two related assumptions have passed into general acceptance and have acquired for orthopaedic surgeons an almost doctrinal significance. The first is that the anterior longitudinal ligament is proof against almost any force, and that against it the extension force used in the reduction of crush fractures of the spine may be applied with safety. Thus Davis (1943) in pointing out that the anterior longitudinal ligament is incompletely elastic and has a rupture strain of 337 lb, writes "By

and large one may say that the anterior longitudinal ligament is secure against horizontal severance either of fracturing force or hyperextension reduction." Most methods of reduction, and most first-aid measures in the handling of fractured spines, are based on this belief (Watson-Jones 1938, Taylor 1929, Platt 1938, Brookes 1937). The second assumption is that if the cervical spine is subjected to

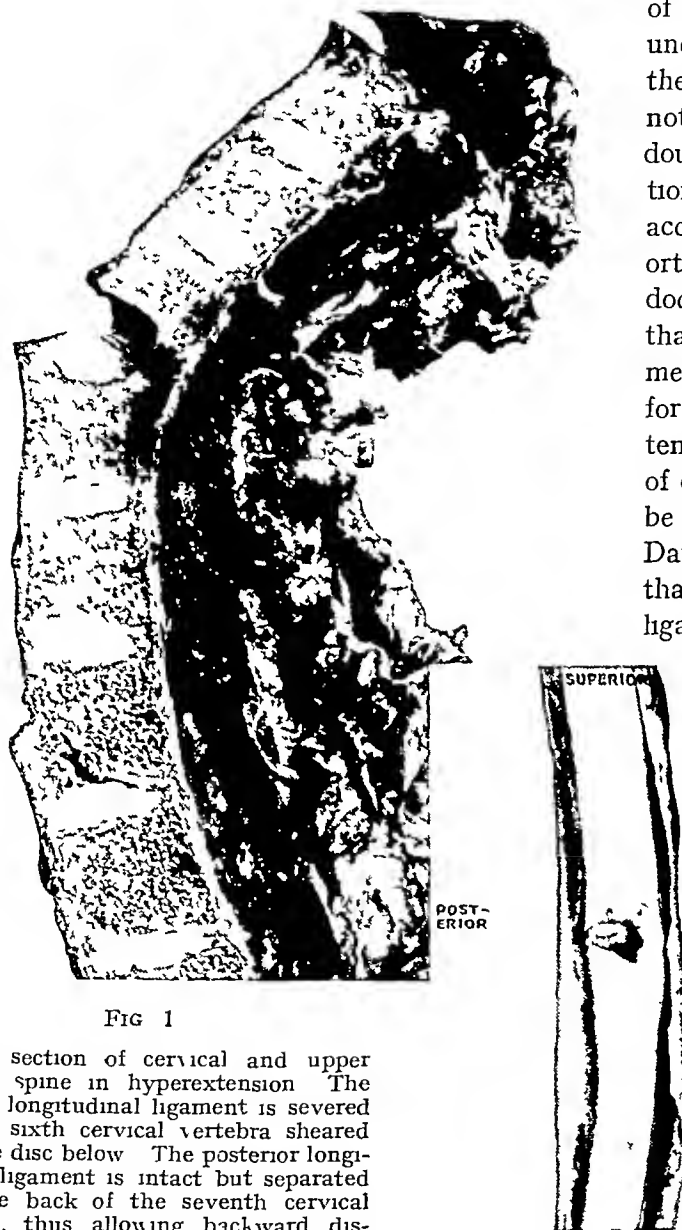


FIG 1

Sagittal section of cervical and upper thoracic spine in hyperextension. The anterior longitudinal ligament is severed and the sixth cervical vertebra sheared from the disc below. The posterior longitudinal ligament is intact but separated from the back of the seventh cervical vertebra, thus allowing backward dislocation with narrowing of the spinal canal.

Inset shows localised contusion of posterior part of spinal cord caused by momentary nipping between the posterior-inferior border of the body of C 6 and the lamina of C 7.

sufficient hyperextension strain the brunt of injury will be borne by the atlas and axis vertebrae which may fracture through one or both arches or at the base of the odontoid process. Both these assumptions are partly true, but no more than partly true. The anterior longitudinal ligament is certainly strong, but it does rupture under sufficient strain, and a backward thrust applied through the head does cause dorsal

dislocation or fracture at the lower levels of the cervical spine. Wilson and Cochrane (1929) report, with autopsy photographs but without radiographs, a case of extension dislocation of the spine at the sixth cervical level with rupture of the anterior longitudinal ligament. W. J. Mixer (1941) envisaged such a case when he wrote, "Posterior dislocation is rare on account of the strong supporting structures, and if it does occur, I believe that spontaneous reduction might easily take place."

**Diagnosis**—The differential diagnosis in cases of paraplegia without radiographic evidence of significant displacement calls for reconsideration. We believe that forward dislocation due to flexion injury with spontaneous reduction is highly improbable. Damaging criticism of this conception has been advanced by Cramer and McGowan (1944). In our view the diagnosis lies between extension dislocation with immediate spontaneous reduction and acute prolapse of an intervertebral disc. These two conditions can be differentiated with relative certainty. The history may indicate clearly whether the injury took place in flexion or extension. Severe facial injury of the type here presented suggests injury in extension. Older patients with fixed kyphotic deformity are still more liable to extension injury. Spinal manometry should be done because the results furnish a useful guide to treatment, particularly in cases of acute disc prolapse, but it does not help greatly in differentiation of the conditions under review. Disc protrusion may or may not cause spinal block, and although hyperextension dislocation does not result in continued narrowing of the spinal canal at the point of injury, yet spinal block may develop later by reason of oedema of the cord due to contusion. Although we have stressed the normal appearances of radiographs, X-ray examination may help by disclosing minor changes. Narrowing of a disc space, or the suspicion of wedging of a vertebra, create a strong presumption that the compressing agent is a ruptured disc. The tearing of a small flake of bone from the anterior margin of a vertebral body suggests rupture of the anterior longitudinal ligament and therefore extension injury. If doubt still exists myelography should dispel it, because a prolapsed disc of sufficient size to damage the cord should be visualised without difficulty.

Mention should be made of another possibility which was suggested by Cramer and McGowan (1944), namely that "recoil" cervical cord injuries are caused by acute "piston-like" retropulsion of the intervertebral disc in hyperflexion, with immediate complete



FIG 2

In the position of flexion the dislocation is completely reduced and the anatomical contours are restored. The spinal canal is no longer narrowed. There is no block on spinal manometry, and radiographs taken in this position reveal no abnormality.

reduction Burns Plewes (1938) made a similar suggestion on the basis of one case studied at autopsy, but unfortunately the anterior longitudinal ligament was not examined, and it is to be noted that the patient had a wound on the forehead, thus suggesting hyperextension injury Unless more definite evidence is forthcoming this hypothesis should be treated with some reserve It seems most unlikely that the inelastic annulus and posterior longitudinal ligament should stretch sufficiently to allow posterior displacement of nuclear material and confusion of the cord without actual rupture

**Treatment**—The practical value of the recognition of hyperextension injuries lies in treatment The extended position in which, by well established usage, all cases of traumatic cervical paraplegia are treated is in fact the position most calculated to inflict further damage to the injured cord If the anterior longitudinal ligament is ruptured the extended position tends to reproduce the conditions of injury, to redislocate the spine, and to narrow the spinal canal at a point where the cord normally bears the greatest ratio of size in relation to the spinal canal We suggest, therefore, that if the diagnosis is made, or even strongly suspected, the patient should be nursed in a shell, or between sandbags, in the neutral position or even in a position of slight flexion

The tone of this paper is perhaps dogmatic It is based on indisputable facts, but they relate only to two cases and there is not yet ground for certainty Nevertheless the facts have been emphasised deliberately in the hope that attention will be focused on the possibility that so-called recoil injuries may be dislocations in extension "Recoil injury" or spontaneous reduction is clearly a reality, and it did in fact take place in our case of posterior dislocation by extension, but we remain sceptical of the occurrence of recoil or spontaneously reducing hyperflexion injuries

**Summary** 1) A case is reported of paraplegia with normal radiographic appearances in which cervical cord damage was shown at autopsy to have been due to hyperextension injury

2) The mechanism of such injuries is discussed, together with the differential diagnosis from acute prolapse of an intervertebral disc

3) The grave dangers of using the fully extended position of the cervical spine in the management of these cases is noted

We acknowledge the helpful advice and criticism we have received from Professor Norman M Dott in the preparation of this paper

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# PRESSURE AT THE CERVICO-BRACHIAL JUNCTION

## An Operative and Anatomical Study

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To older workers the problems of the cervical rib seemed simple and straightforward. The patient complained of pain and weakness in the hand, radiographs disclosed a cervical rib, and symptoms were attributed to a hang-up of the plexus on the abnormal rib. Pressure became excessive, chiefly at the age of thirty to forty years, as the result of drooping of the shoulder girdle and it might be made worse by a post-fixed plexus. This no doubt is still true of most cases to-day, but increasing experience has shown that the subject is by no means so cut and dried as had been thought. A number of patients whose symptoms were typical showed no cervical rib on radiographic examination, radiologists reported frequent examples of cervical rib without ill consequences, and moreover it became clear that some patients were suffering from extensive thrombosis in the arteries of the hand and arm. The subject appealed to many observers and an extensive literature accumulated, much of it consisting of armchair theory supported only by isolated cases. In this article, which is based upon a fairly extensive operative and anatomical experience, an attempt is made to sort facts from fallacy in an admittedly difficult and controversial subject.

In any review it is clear that an appeal to findings at operation is of first importance. We are able to summarise the actual findings in a personal series of 122 cases operated upon by one of us (E D T) between 1908 and the present date. Of these there were seventeen in which the usual symptoms were accompanied, and to a great extent overshadowed, by complications.

**Cases with complications**—Fifteen patients, all with a well-developed cervical rib, showed extensive arterial thrombosis. In twelve of the fifteen, thrombosis extended no higher than some point between the bifurcation of the brachial artery and the lower border of the pectoralis major, the second and third stages of the subclavian artery were entirely normal, no evidence of pressure was seen, and the vessel lay quite loosely on the rib. In three of the fifteen patients, gross abnormality of the artery was found—namely a thrombosed aneurismal dilatation firmly fixed to adjacent structures by much periarteritis. The upper limit of the aneurism in two of these three cases was 1 cm. distal to the rib, the artery where it lay on the rib was normal. In the third case the proximal part of the aneurism overlaid the cervical rib.

In two other patients the chief complaint was hyperhidrosis of the hand, sufficiently severe to interfere with work. In one of these, the cause was a well-formed cervical rib, and in the other a taut fibro-cartilaginous band representing the forward end of a rudimentary cervical rib.

**Uncomplicated cases**—These number 105 and they may be classified according to the findings at operation into several groups

Pressure by fibrous band	12 cases
Abnormal disposition of scaleni	8 "
Cancellous osteoma	2 "
Deformed thoracic outlet, pressure of clavicle on first rib	8 "
No obvious cause found	5 "
Cervical rib	70 "
	<hr/>
	105 cases

*Pressure by fibrous band*—In twelve patients the pressure on the lowest trunk of the plexus was due to a strong taut band springing from the tip of a small and pointed rudimentary rib. This band passed downwards and forwards in the anterior border of scalenus medius. It was easy to demonstrate that on deep inspiration the band was tautened, thus lifting the lowest trunk of the plexus which in most cases showed a permanent notch at the point of contact with the band.

*Pressure due to abnormal disposition of the scalen*—In eight patients the tendinous insertion of scalenus medius into the first rib was carried forwards farther than usual with the result that the lowest trunk of the plexus and the artery were not in contact with the first rib but were raised by the narrow V formed on one side by the lateral tendinous edge of scalenus anterior and on the other by the sharp anterior border of scalenus medius. In all these cases detachment of part of both muscles resulted in cure.

*Pressure due to cancellous osteoma*—In two patients, both girls aged fourteen years, the cause of pressure was a large irregular cancellous outgrowth at the point where a well-developed cervical rib joined the first thoracic rib.

*Pressure of clavicle on first rib in deformed thoracic outlet*—In eight cases the symptoms cleared completely after resection of part of a first thoracic rib. These are probably examples of a deformed thoracic outlet, usually due to cervico-dorsal scoliosis. In six earlier operations the significance of this was not appreciated, but in the last two patients who were operated upon, distinct scoliosis with asymmetry of the thoracic outlet was recognised.

*No obvious cause of pressure*—In five instances most thorough exploration failed to disclose any cause of pressure and unfortunately these patients were not relieved. They may have been examples of prolapse of an intervertebral disc or brachial neuritis.

*Pressure due to cervical rib*—The other seventy cases showed cervical ribs in various stages of development. The word "cervical" is used in a descriptive and not in a strictly anatomical sense. It has often been pointed out that these ribs do not always spring from the seventh cervical vertebra and that occasionally they are rudimentary and deformed first thoracic ribs. This possibility can be determined easily by means of antero-posterior radiographs taken by the moving mandible technique which permits accurate counting of the vertebrae from above downwards.

In each of these seventy cases special attention was paid to the possibility of evidence of injury to the plexus or artery such as might be exerted by the clavicle. In sixty-seven cases most careful inspection failed to show outward or visible signs of injury by pressure, but the majority showed a distinct and permanent notch in the lowest trunk of the plexus where it lay against the rib. The nerve trunk had been hung up and angulated by the upper border of the cervical rib.

In three of these patients an abnormal condition of the artery was found. Beginning 1 cm. distal to the rib there was a symmetrical, fusiform aneurism extending some 2.5 cm. down the vessel, at the widest part of the aneurism the artery was dilated to fully twice its normal size. These three patients differed completely from those already described with aneurism, thrombosis, and periarteritis, in that the artery was pulsating normally and that in none was there thrombosis, the circulation was normal throughout the limb. It would seem fair to presume that these simple uncomplicated aneurisms represent an earlier stage in the pathology of thrombosis. This point may be of importance in discussing the causes of thrombosis and will be referred to later.

It is clear from this analysis of 122 operations that the causes of pressure on the neuro-vascular bundle are many and varied. No one explanation such as costo-clavicular pressure, or scalenus anterior "spasm," can account for all cases. Of the many controversial points three at least appear to be worthy of more detailed discussion, namely 1) the scalenus anterior syndrome, 2) the costo-clavicular syndrome, 3) the cause of arterial thrombosis.

## THE SCALenus ANTERIOR SYNDROME

Although Murphy (1905) described a case in which a cervical rib was found to have compressed the neuro-vascular bundle against the lower end of scalenus anterior, and Adson and Coffey (1927) reported four similar cases, it was not until 1935 that the term "scalenus anticus syndrome" was coined by Ochsner, Gage, and De Bakey. Some confusion has since arisen in the scope and meaning of this term. There are authors who regard it as synonymous with the title of the present paper, and expressions such as "scalenus anticus syndrome with or without cervical rib" have been used. We prefer to restrict the term to those lesions in which the scalenus anterior is the sole or the main provocative factor, or in other words to those cases in which no symptoms would have arisen had it not been for this muscle.

Since 1935 much literature has accumulated, perusal of which shows so many different and conflicting views that the only conclusion left to the reader is that they cannot all be right. From this welter of opinion two groups may be distinguished. In one the action of scalenus anterior is considered to be passive and mechanical, in the other a condition of spasm is assumed. In this latter group the damage is said to be caused by active contraction of the muscle.

*Passive action of scalenus anterior—*

Pressure on the neuro-vascular bundle by the scalenus anterior against the forward end of a cervical rib as first described by Murphy (1905) will be found occasionally in any large series of cases. It is more likely to happen if the prominence on the first rib, to which the accessory rib is articulated, is unusually large. Matters are made worse when the muscle presents a sharp tendinous edge towards the cervical rib. In an examination of sixty-four muscles we found the costal insertion of scalenus anterior to be entirely tendinous in thirty-six instances. The condition is well illustrated by the case of a girl aged fourteen years on whom we operated for very acute

symptoms and found the condition shown in Fig. 1. Another factor is the variation in size of the muscle in different subjects. Increased width of insertion is very common. Reed and Weed (reported by Gage and Parnell 1947) give important figures showing the wide range in measurement, their figures agree closely with those of our own series which are:

Width of scalenus anterior insertion—0.4 to 2.5 cm

Inter-scalene interval on the first rib—0 to 2.4 cm

Chondro-sternal junction to medial edge of scalenus anterior—2.4 to 6.0 cm

In view of this variability too much importance cannot be attached to reports that the scalenus anterior was found to be "hypertrophied."

Occasionally the muscle presents a very sharp, recurved, and falciform type of insertion which might cause acute pressure on the lowest brachial trunk. This condition was noticed

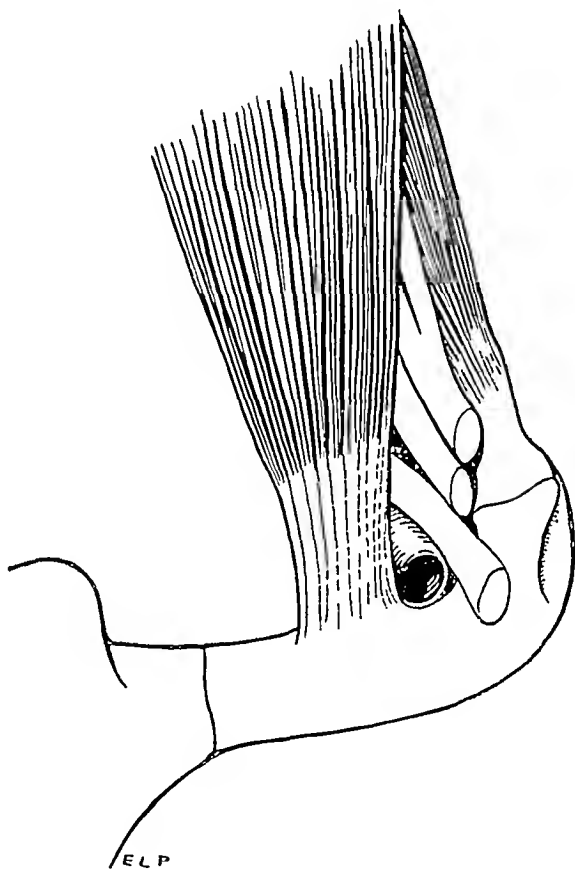


FIG. 1

Compression of the subclavian artery and inferior trunk of the plexus between scalenus anterior and the forward end of a cervical rib

twice in 102 dissections (Fig 2) The scalenus anterior may also give rise to trouble when its insertion is wide and there co-exists an extension forwards of the insertion of scalenus medius. This is illustrated by the diagram of a dissection (Fig 3) It results in the formation of a V on which the plexus bundle is hung up with likelihood of damage to the lowest trunk.

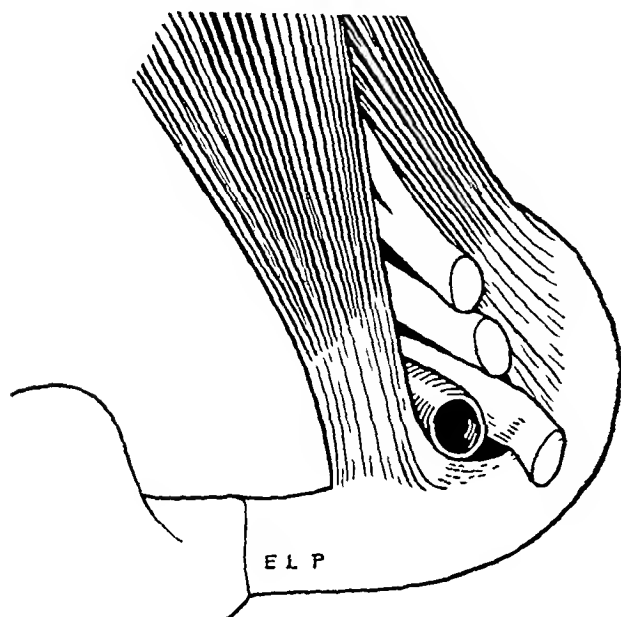


FIG 2

The rare falciform type of insertion of scalenus anterior

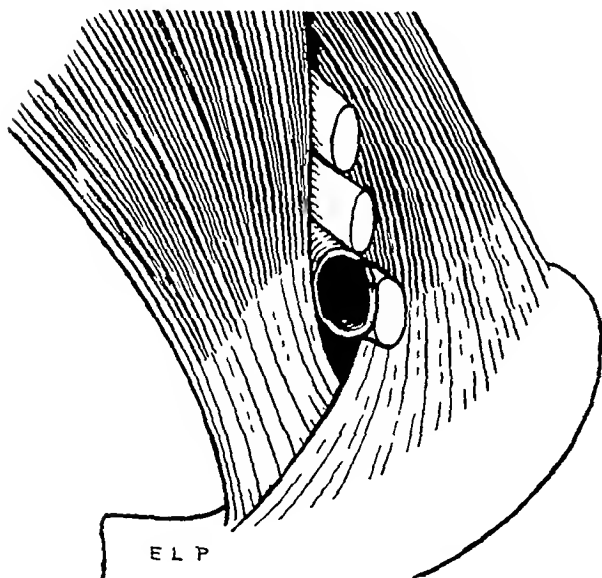


FIG 3

The V type in which the insertions of scalenus anterior and scalenus medius overlap

cause pressure on the nerve roots tendinous slips from the costo-transverse bars would have to be directed downward and backward to the neighbourhood of the neck of the first rib.

Very occasionally it will be found at operation that the subclavian artery appears to pass through the substance of scalenus anterior so that about one-third of the muscle lies posterior to the vessel, which is itself quite normal. In some of these the muscle deep to the

We have met this condition at operation on eight occasions and in fifteen of 102 dissections in the cadaver. Fig 4 demonstrates the more usual pattern of the scalene insertions.

Naffziger and Grant (1938) suggest that there is a natural tendency for the neuro-vascular bundle to slide ventrally and that it is restrained by the scalenus anterior. We have never seen any shift of the bundle after cutting the muscle in the living patient, in the post-mortem body, or in the dissecting room subject.

Swank and Simeone (1944) suggested that the sixth and seventh cervical nerve roots might be compressed by the tendons of origin of the muscle. With this point in view twenty-four dissections were carried out. In twenty we found no possible evidence that nerve roots could be compressed by the tendinous origins of the muscle because they were protected by the anterior tubercles of the transverse processes. There were, however, four dissections in which some tendinous fibres were attached to the costo-transverse bar of the fifth and sixth cervical vertebrae. The tendinous slips lay between the fifth and sixth, and the sixth and seventh nerve roots respectively, they passed downwards and antero-laterally to join the lateral aspect of the rest of the muscle belly. There was no evidence of pressure on the sixth and seventh cervical nerves which were placed loosely between slips of attachment of the two scalene muscles. The disposition of these tendinous slips in relation to the nerve roots was such that it was difficult to believe that injurious pressure could be caused either at rest or in action. The impression gained was that in order to

artery may be the scalenus minimus (muscle of Albinus) In 34 per cent of our dissections we found a band of muscle arising from the transverse process of the seventh cervical vertebra and ending in a slender rounded tendon attached to a small spin on the inner margin of the first rib at a point between the two scalen. This tendon passes between the artery and plexus. It is quite possible for this muscle to be a cause of injurious pressure. We have noted in one cadaver a groove, caused by the muscle belly, imprinted on the first thoracic nerve as it crossed the neck of the first rib (Fig 5). Indeed Falconer and Weddell (1943) reported a case which was treated successfully by simple division of the costo-vertebral ligament the ligamentous representative of scalenus minimus.

From our own experience in the Neuro-vascular Clinic in Manchester we concur with Nachlas (reported by Tanna 1947) who points out that many patients have shown no improvement after scalenotomy. On the other hand there are, beyond doubt, some who have been cured. These fortunate few belong to the group in which the action of the scalenus anterior is passive and mechanical.

#### Active action of scalenus anterior—

In this group mischief is attributed to the scalenus anterior by reason of spasm, disease, or injury. It is stated by some writers that the anterior scalene muscle holds up the first rib and that when the muscle is cut there is a notable drop of the rib. Apart from the fact that the scalenus medius which is a much more powerful muscle is still intact, we can say only that in the course of 470 anterior scalenotomies performed on the living, the great majority during thoracic sympathectomy by the anterior route, we have never seen this happen. Moreover Swank and Simeone (1944) who carried out radiographic examinations after unilateral scalenotomy say that they saw no change in the position of the rib relative to the rest of the thoracic cage. We agree entirely with their dictum "It is unlikely

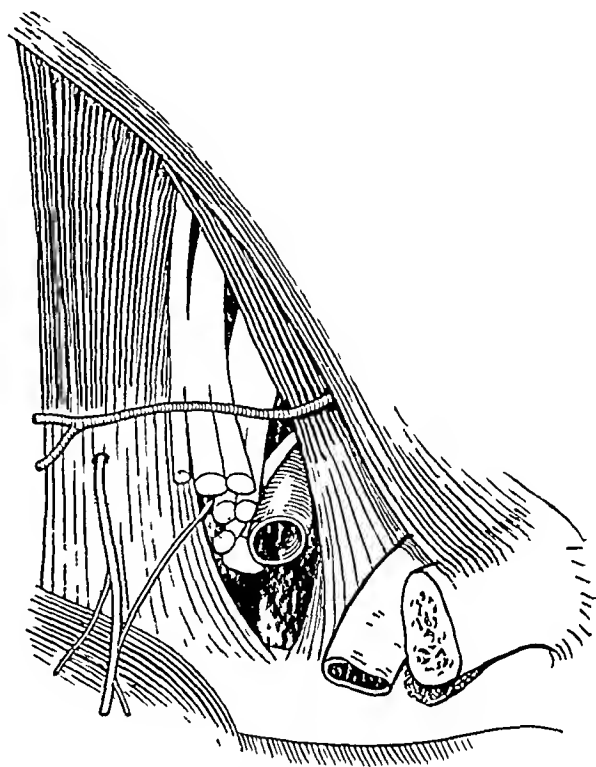
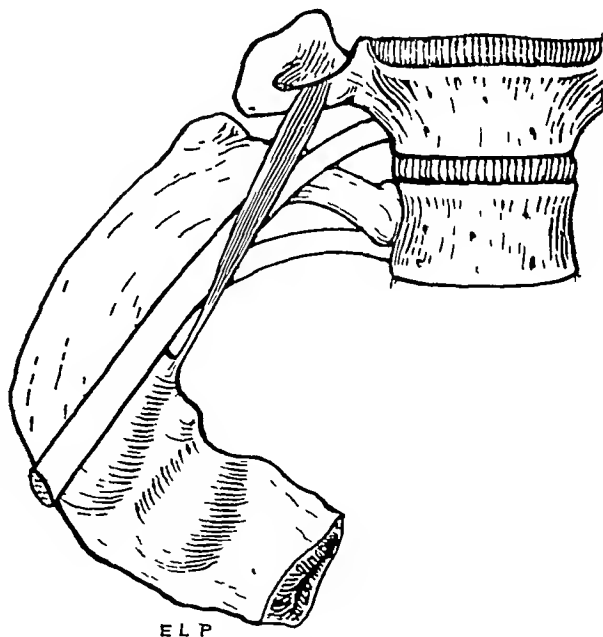


FIG 4

The normal pattern of insertion of the scalenus anterior and scalenus medius



ELP

FIG 5

Scalenus minimus (muscle of Albinus) compressing the first thoracic nerve root

that the scalenus anterior in the adult is responsible for significant independent motion of the first rib." Even if it were responsible for significant elevation of the rib it is not true



to say that when in spasm it would compress the nerve trunks against the rib. On the contrary the angle between the lateral border of the muscle and the first rib would be increased under these conditions.

If this be so, what of the theory of spasm of the muscle, and why should it develop spasm? It is not easy to understand why a relatively small muscle such as the anterior scalene should be affected by spasm while its larger companion, the scalenus medius with the same nerve supply, escapes. A vicious circle has been assumed by some observers. Brachial plexus irritation is believed to cause spasm of the scalenus anterior which in contracting aggravates irritation of the plexus. But the customary site of irritation of the plexus is far below the point of origin of the nerve supply to the muscle, and even if a source of irritation nearer to the exit of the nerves from the vertebral foramina was assumed, much more widespread spasm would be expected. In support of the theory of scalenus anterior spasm four suggestions have been made. The first is that degenerative and fibrotic changes have been found on biopsy of the muscle, but it is doubtful whether much value can be attached to these observations. Some years ago, in the course of an inquiry into the tissue changes of sclerodactyly and dermatomyositis, one of us (E D T) removed for section the posterior belly of the omohyoid in eight individuals. The reports which were returned by the same experienced pathologist differed so widely that no definite conclusion could be made. A second suggestion is that there is tenderness over the muscle on deep pressure. Deep tenderness is usually present in cases of pressure on the neuro-vascular bundle, but we have found considerable difficulty in deciding that it was in the scalenus anterior and not in the trunk of the brachial plexus which is immediately adjacent. A similar objection holds for the third argument, which is that injection of the muscle with a local anaesthetic has relieved the symptoms. It is not easy to be assured that no structure other than the muscle has been anaesthetised. If radio-opaque material is added to an injection it is chastening to see on the radiographic films how widely the most precisely placed injection has spread. Fourthly it has been suggested that spasm of the muscle is caused by trauma. Not only is it difficult to envisage the cause of such injury, but it is necessary also to explain why such trauma should operate especially in women aged thirty to forty years.

In recent years there has been in Great Britain increasing doubt as to the existence of a scalenus anterior syndrome as a definite entity. From our experience we think that this attitude is well grounded. Our own view is that there cannot be justification for the pre-operative diagnosis of "scalenus syndrome" which is believed to warrant an operation directed solely to section of the anterior scalene. Such an attitude is certain to end in frequent disappointment and failure.

### THE COSTO-CLAVICULAR SYNDROME

Some workers have insisted on pressure by the clavicle as an important cause of damage to the neuro-vascular bundle. Much of this writing can fairly be criticised as imaginative and unrealistic. For example, diagrams are sometimes drawn to show how the clavicle acts as one jaw of a clamp or vice compressing the artery against the first rib on depression of the shoulder. The accuracy of these diagrams is questionable because the clavicle does not travel in a two-dimensional plane, it moves in three dimensions. Furthermore, stress has been placed on the fact that in some positions of the shoulder there is diminution or arrest of the radial pulse. We hope to show that in the normal individual the clavicle is not concerned in this phenomenon which is due to causes operating distal to that bone. We have made careful and lengthy inquiry into the part played by the clavicle and our findings may be given under two headings: a) the effect of shoulder position on the radial pulse in normal persons, b) the part played by the clavicle in causing neuro-vascular complications.

**Effect of shoulder position on the radial pulse**—Investigations were made in 120 medical students, seventy men and fifty women, thus totalling 240 arms for examination. Oscillo-

metric observations were attempted but they were soon discarded as unreliable. In depression of the shoulder, as in carrying a heavy weight by the side, there were 116 instances of diminution and thirty-eight of arrest of the pulse, in other words 64 per cent of examinations showed some alteration of the pulse. In retraction of the shoulder, as in "throwing a chest," the radial pulse was weakened in 134 cases and arrested in thirty, there was alteration in 68 per cent of examinations.

The results in abduction of the limb were of special interest. In full abduction there was some alteration of the pulse in 54 per cent. In abduction to 90 degrees the pulse was weakened in no more than 7.5 per cent. If, however, with the arm at a right angle to the body the subject was asked to adduct the arm while the observer restrained the movement, some alteration of the pulse was found in no less than 90 per cent. This would seem to indicate that the artery was compressed by muscular action. It is remarkable that arrest of the radial pulse has been tacitly assumed to be due to clavicular pressure. This cannot be true, because in cases where the radial pulse was arrested during shoulder depression it was usually easy, especially in spare and not very muscular subjects, to feel normal pulsation in the upper part of the axillary artery below the clavicle. Our attention was drawn to this fact at operation in a young man who complained of severe aching of the hand on using the arm in a dependent position. Even moderate depression of the shoulder arrested the radial pulse but left a normal pulse in the axillary artery. The upper portion of the axillary artery and adjacent nerve trunks were exposed fully and it was seen that on pulling the arm down by the side of the trunk, the artery was gripped and closed by the two heads of the median nerve.

In view of this striking and unexpected finding we decided to review the anatomy of the axillary artery. Dissections were carried out with the arm by the side. From fifty-four dissections it was found that the vessel pursued one of two different courses. In thirty-four specimens (63 per cent) the subclavian artery, after emerging from behind the scalenus anterior, crossed the first rib obliquely and continued downwards and outwards into the axilla until it reached the neighbourhood of the second rib. Here it turned laterally for one and a half centimetres and then made a second bend to pass into the arm. In the remaining twenty dissections the vessel made its lateral curve opposite the upper part of the first interspace, near the outer border of the first rib, before continuing downwards into the axilla. This cirroid course of the artery was described by Todd (1911) in subjects with cervical ribs and as a normal occurrence in the foetus. It appears from the present study to be a normal feature in adults when the anatomy is not distorted by abduction of the arm to 90 degrees (which of course is usual practice in the dissecting room). The cirroid course is obviously designed to allow free movements of the shoulder in all directions without causing undue tension on the artery. Subject to individual variations the general relations of the brachial plexus to the first part of the artery in the two types were as follows. In the first the nerve cords were arranged one postero-laterally, one posterior, and one postero-medially to the vessel. The two heads of the median nerve arose from the plexus at the point where the artery turned laterally and lay directly in front and behind the vessel, enclosing it in a scissor-like grip. Not infrequently the cords were grouped along the lateral aspect of the vessel as shown in Fig. 6, thus accentuating the gripping effect of the median nerve heads. In the second type the three nerve cords lay respectively on the anterior, postero-medial, and medial aspects of the artery causing the two heads of the median nerve to be situated antero-medial and medial to the vessel (Fig. 7).

Depression of the shoulder by pulling the arm alongside the trunk caused the axillary artery to be constricted by the heads of the median nerve in the first type. In the second, the disposition of the median nerve heads was such that constriction of the vessel could not possibly occur. Resection of the first rib caused no alteration in the plexus-artery relationship. We were not able to confirm the finding of Wright (1945) that during abduction of the

arm the axillary artery is hooked up under the coracoid process. As the arm is abducted the neuro-vascular bundle rises, but the coracoid process also moves backwards and upwards owing to scapular rotation consequent on abduction. In no dissected subject could the neuro-vascular bundle be said to approach nearer than two and a half centimetres to the coracoid process in whatever position the arm was placed.

It would appear then that approximately two-thirds of individuals possess a plexus-artery relationship such that forced depression of the shoulder interferes in some degree with the circulation through the axillary artery.

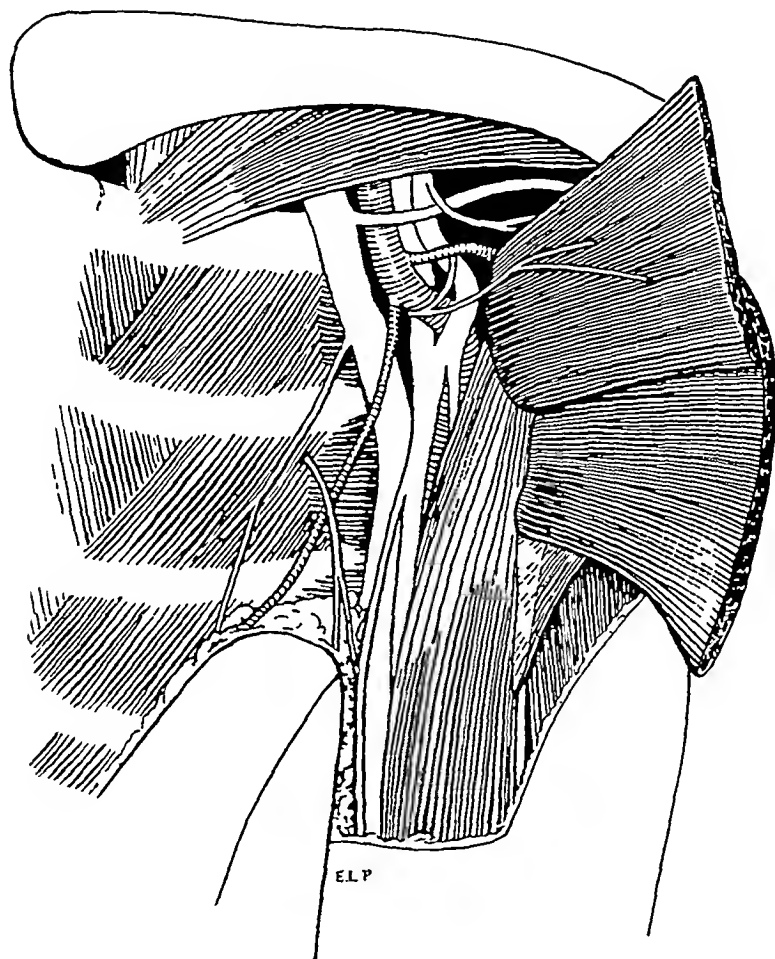


FIG 6

Disposition of nerves relative to the axillary artery in cases where depression of the shoulder causes arrest or diminution of the radial pulse—found in thirty-four out of fifty-four dissections

It remains to explain the alteration of the radial pulse in retraction and abduction at the shoulder. In view of the fact that excursion of the clavicle during retraction is almost identical with that during abduction it would seem likely that one explanation will hold for both movements. It is interesting to note that in many of those subjects in whom the radial pulse is modified or abolished by full abduction the alteration in pulse is temporary—that is to say that if abduction is maintained the pulse returns to normal. We interpret this temporary diminution of pulse during abduction as being due to compression between the subscapularis and pectoralis minor muscles, which are contracting as synergists during abduction, and the return of pulse to the lessening of contraction of these muscles once the position of abduction has been obtained.

This view is confirmed by the observation that in simple abduction to 90 degrees only 75 per cent of subjects showed any change in the pulse, but if in this position voluntary adduction was forcibly resisted the number of instances of interference with the pulse rose to no less than 90 per cent.

**Possible effect of the clavicle in compressing the artery or plexus**—As a further stage of this inquiry we carried out an investigation into the movements of the clavicle in fifty bodies. In formalin-hardened bodies certain shoulder-girdle muscles had to be divided in order to allow of a full range of clavicular movement. To avoid possible error from this muscle division, ten fresh post-rigor bodies were studied in the post-mortem room.

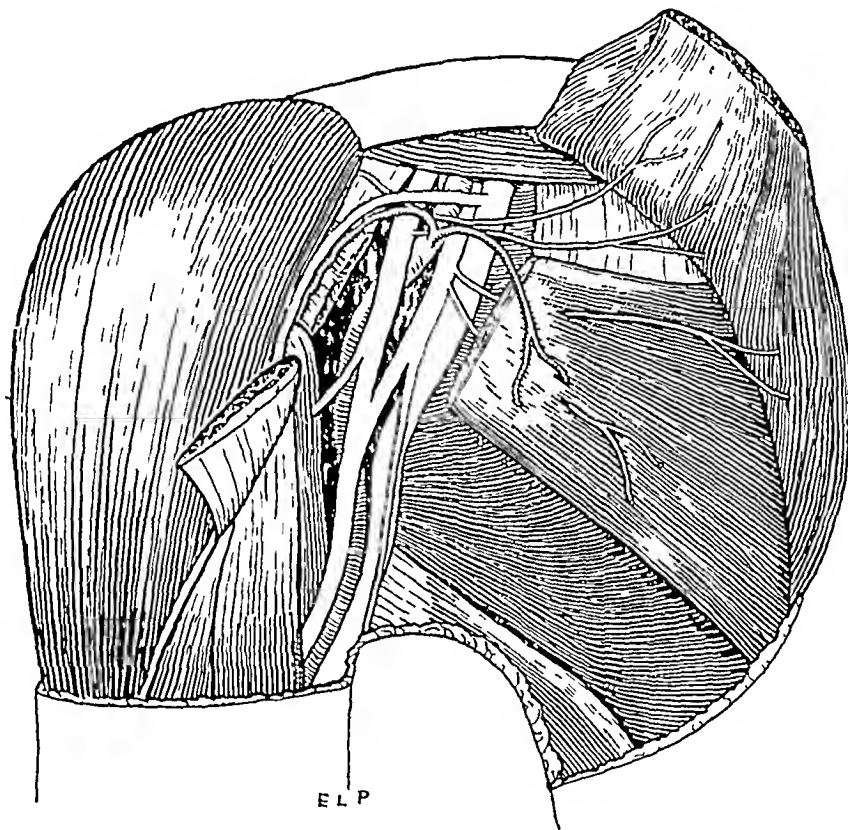


FIG 7

Arrangement of the nerves relative to the artery which renders impossible any compression of the vessel between the two heads of the median nerve—found in twenty out of fifty-four dissections

The findings were essentially similar in both sets of bodies. Wherever possible the measurements have been compared with similar ones obtained in the living subject, and have been found to agree very closely. Todd (1912) measured the angle of clavicular elevation by placing one limb of a pair of calipers upon the upper surface of the clavicle so as to touch the bone at the sternal and the acromial ends, and adjusting the other limb to the horizontal. He pointed out that this is an oblique measurement and does not represent the true vertical elevation of the clavicle but is the clinical measurement in the living subject.

The true vertical elevation of the clavicle can be found from radiographs or by calculation from measurements with a special instrument. We have called the angle measured by Todd's method the "clinical angle" and the elevation measured on radiographs or by instruments the "true angle" of elevation. These angles differ considerably, the "clinical angle" being the larger.

All angles and distances mentioned are average figures since individual variation is wide in the shoulder-girdle region. In the majority of adults with the shoulders at rest, true clavicular elevation, *i.e.*, the angle at which the clavicle is raised above a horizontal line passing through the upper margin of the manubrium sterni, is between 0 degrees and 10 degrees, average 6 degrees (clinical angle 20 degrees). The distance between the nearest point on the clavicle opposite to the subclavian artery, and the first rib is 3.2 cm.

When the shoulder girdle is pressed backwards in the dead body, as when the shoulders are retracted in the living, the acromial end of the clavicle rises and the bone comes to lie across the root of the neck above the level of the first rib. The true angle of clavicular elevation then measures 16 degrees (clinical angle 30 degrees) and the distance between the clavicle and first rib, opposite to the subclavian artery, is 1.7 cm. During this movement of retraction the clavicle has also rotated 5 degrees in its long axis so as to present its superior surface posteriorly. This upward and postero-medial excursion of the clavicle does not take place in a straight plane. The clavicle describes an arc pivoting on the costo-clavicular ligament.

The excursion of the clavicle during abduction is essentially similar to that during retraction. The true angle of elevation, however, is increased to 22 degrees (clinical angle 40 degrees) and rotation in the long axis of the bone measures 30 degrees, owing to the extent of scapular rotation on the chest wall consequent on full elevation of the arm. With regard to the suggestion that the clavicle compresses the artery against the first rib during these movements the minimum distance measured between the two bones was 1.5 cm. At no point did the clavicle impinge on the subclavian artery.

When considering the question of costo-clavicular pressure, clavicular rotation is an important event. With the shoulders at rest the medial two-thirds of the bone is curved with its convexity directed anteriorly. When the clavicle lies across the root of the neck this convexity forms an arch over the neuro-vascular bundle, owing to the rotation that has accompanied full abduction or retraction of the shoulder (Fig. 8). Doubtless this is nature's method of avoiding pressure by the bone structures on the soft parts.

During the movements of abduction and retraction of the shoulder it was noticed that the tendon of the subclavius muscle compressed the subclavian vein against the first rib (Fig. 6) but at no point did the clavicle itself interfere with this vessel.

From the position of full abduction or retraction to that of full depression of the shoulder, the clavicle describes an arc moving downwards and forwards. The more the shoulder is depressed the more forward does the clavicle move, thus widening the costo-clavicular interval. At full depression this measured 3.7 cm. opposite the subclavian artery, *i.e.*, an increase of 0.5 cm. when compared with the position at rest. In order to press the clavicle directly on to the vessels and nerves as they cross the first rib it was necessary to open the sterno-clavicular joint and sever the intra-articular disc.

With regard to the plexus and artery during depression of the shoulder it was seen that the superior and middle trunks, together with the contribution from the seventh cervical root to the nerve to serratus anterior, were tightly stretched across the tendinous antero-medial edge of the scalenus medius (Fig. 4). The inferior trunk was pulled down into the angle of junction between the scalenus medius and the first rib. It was not possible by this manoeuvre to compress the artery against either of the scalene muscles, nor was there any evidence that the plexus moved anteriorly toward the costal insertion of the scalenus anterior when the arm was depressed. Thus it will be appreciated that when the shoulders are retracted or abducted the girdle moves *upwards* and postero-medially, and during depression in the reverse direction. Such statements which have appeared in the literature on this subject as "downward and backward retraction" or "downward and backward bracing" of the shoulder can therefore have no meaning.

It would seem that in individuals with normal anatomy the clavicle can play no part in compressing the artery or plexus against the first rib. Only if the costo-clavicular interval is narrowed, from any cause whatsoever, is it possible that the movements of retraction and abduction of the shoulder may lead to pressure symptoms.

Fresh interest has recently been aroused in movements of the clavicle in relation to the first rib by reason of the large number of patients with paraesthesia of the hands who have

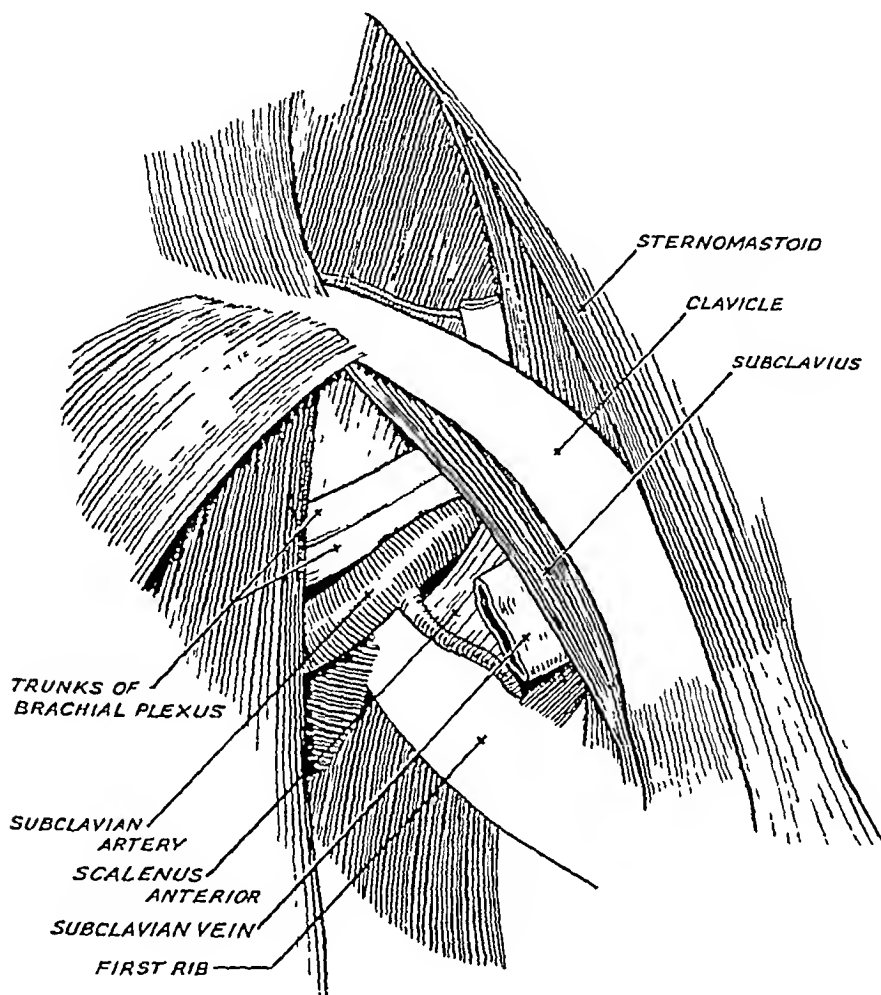


FIG 8

Illustrating how rotation of the clavicle in its long axis causes the anterior convexity of its medial two-thirds to form an arch over the neurovascular bundle (arm abducted to 90 degrees)

been seen in neurological and neuro-vascular clinics in Great Britain during the latter part of the war and since that time. They are almost entirely middle-aged women suffering from overwork and under-nourishment. They have been forced to do unaccustomed heavy work, to stand for many hours in queues, and to carry heavy shopping baskets. The pain is severe and it often precludes proper sleep. Many have discovered trick positions of the arms which give some ease, the one feature common to these positions being moderate but not complete abduction, thus taking strain off the shoulder-girdle muscles. The pain in these cases is not due to clavicular pressure because in a normal individual the more the shoulder is depressed the wider becomes the costo-clavicular interval. They are, we believe, due simply to drag of the plexus across the tendinous anterior edge of the scalenus medius such as is seen when the arm of a dissected body is pulled downward. Loss of tone in the shoulder-girdle musculature in these middle-aged women is no doubt an important contributory factor.

## THE PROBLEM OF THROMBOSIS

Arterial thrombosis is an occasional and grave complication of cervical rib. In our 122 patients it was found in fifteen (12 per cent). Its explanation is not yet fully understood. Todd (1913) believed that paralysis of sympathetic fibres led to thrombosis. Telford and Stopford (1931) carried this work a stage further and pointed out that a leash of undistributed sympathetic fibres was sometimes found in the lowest trunk of the brachial plexus at the point of pressure. Irritation of these fibres would lead to arterial spasm and finally thrombosis, as occurs in ergot poisoning and in old-standing Raynaud's disease. This view was confirmed by Blair, Davies, and McKissock (1935) who, however, thought that the pressure resulted in neuritis of that part of the trunk which contained the sympathetic fibres.

This idea of sympathetic irritation was strongly criticised by Lewis (1934) and later writers, who held that the cause of thrombosis was serious direct injury to the artery where it crossed the rib. Certain facts may, however, be accepted as evidence in favour of the sympathetic irritation theory. We have observed very gradual onset with pallor and coldness of

the hand, increasing at the end of a day of hard work, and showing much recovery after the night's rest. The variability is such that by some writers the condition has been included, we think wrongly, as one form of the Raynaud phenomenon. Moreover in twelve of our fifteen operations for thrombosis, not the slightest evidence of damage to the artery where it crossed the rib has been seen, but all cases have shown a large cervical rib actually grooved by the lowest trunk of the plexus (Fig 9). Furthermore the occurrence of two cases of hyperhidrosis, cured by removal of pressure on the lowest trunk of the plexus, is strong evidence for the theory of sympathetic irritation. There would seem to be good



FIG 9

Excised portion of a cervical rib showing the groove made by the inferior trunk of the plexus

grounds for the view that in some cases, probably the majority, the cause of thrombosis is long-continued intermittent arterial spasm.

This view, however, will not explain the six cases in our series of operations in which gross abnormality was found in the artery. It will be remembered that of these, three were simple aneurismal dilatations without vascular complications, while the other three showed thrombosis with much periarteritis and extensive thrombosis lower down the arm which was no doubt embolic in origin.

It seems reasonable to suppose that the simple aneurism, uncomplicated by thrombosis, represents an earlier stage in the evolution of the disease. No doubt, after a time, the aneurism becomes thrombosed suddenly as the result of further stretching or repeated trauma. The final incident is rupture of the intima with immediate thrombosis. In this connection a recent experience is of interest. A girl aged fourteen years had for some months devoted all her spare time to playing a primitive game of fives against a wall of the house with a soft rubber ball. Her mother had reproved her frequently for wasting so much time. One day she played both morning and afternoon, and in the evening came into the house saying that her left hand was numb and cold. Her mother noticed that the hand was white but she did not seek advice for forty-eight hours, by which time there had appeared two black patches, one on the pulp of the index finger and a second on the dorsum of the hand. She was admitted to the Neuro-vascular Clinic of the Manchester Royal Infirmary as an emergency and operated upon at once. Springing from the seventh cervical vertebra there was a large true cervical rib which articulated at its anterior extremity with a prominent boss on the first thoracic rib, just lateral



to the scapula tubercle. The segment of the artery lying on the rib was normal but just below the rib there was an aneurismal dilatation solidly thrombosed and with much recent acute perianteritis (Fig. 10).

The anterior end of the cervical rib was removed together with the prominence on the first rib. The gangrenous patches resolved quickly and within a month the limb, although without palpable pulse, was normal in appearance and function. The girl was asked to show how she played the game, it was clear that each blow given by the hand to the ball was preceded by strong retraction of the shoulder by which to reinforce the stroke, thus leading to trauma between the clavicle and the cervical rib.

The aneurism found in this case must have existed for a long time and caused no symptoms until the final and sudden catastrophe of thrombosis. It is likely that sudden and massive clotting followed rupture of the overstretched intima.

It is interesting to speculate as to why an aneurism of the vessel may be formed distal to the point of contusion. A link is at once suggested with the experiments of Halsted (1916). He demonstrated that after constricting an artery by an encircling metal band the vessel showed dilatation distal to the band. Halsted explained this result by physical changes in the blood-flow. It may not, however, be safe to apply deductions from the experiment of a permanent metal band to cases where the cause is an infinite series of small contusions of the arterial wall.

It has been suggested that the aneurism may be caused by weakness consequent on damage to the vasa vasorum. In uncomplicated aneurisms, however, there is no naked-eye evidence to support this theory, the arterial wall appears uninjured, it is resilient and shows no evidence of ill-health. We would suggest that the cause may lie in paralysis of the vaso-motor nerves which degenerate as the result of repeated contusions. Secondary dilatation and stretching of the denervated middle coat would extend distal to the site of injury just as far as the point at which the next nerve relay came in. Kramer and Todd (1914) found that the nerve supply of the subclavian artery and proximal part of the axillary artery was derived from the inferior cervical ganglion by a perivascular plexus, and that the first recruitment from a somatic nerve entered the distal portion of the axillary artery. As would be expected considerable variation was found in the origin and distribution of the nerve filaments running to the vessels. We have repeated the work of Kramer and Todd with respect to the subclavian, axillary, and upper portion of the brachial arteries, checking the findings in our dissections by histological examination of such fibres as we took to be nerves. The importance of this is shown by the fact that quite frequently a filament, confidently assumed to be a nerve, proved on section to be a minute artery—a vas nervorum surrounded by its fibrous sheath.

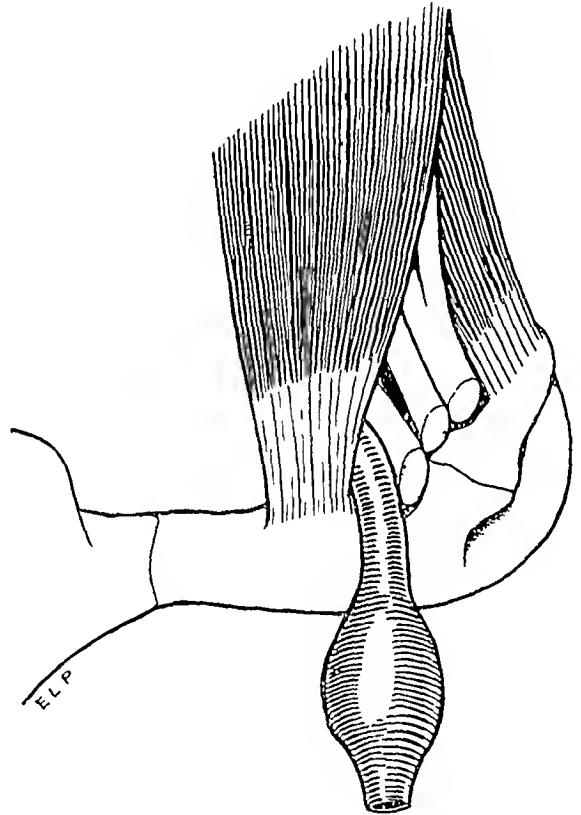


FIG. 10

A typical aneurism. Drawn from the case of the girl described in the text.



We found, as did Kramer and Todd, that dissection of the formalin-hardened cadaver was profitless for this type of work. Accordingly fresh material was obtained from eleven post-mortem bodies. We confirmed the fact that the subclavian artery and the proximal part of the axillary artery are supplied by a perivascular plexus derived from the inferior cervical sympathetic ganglion. From four of the post-mortem specimens filaments running from the plexus to the axillary artery were dissected and proved on section to be definite bundles of nerve fibres. The first of these was derived from the lateral cord of the brachial plexus and entered the arterial coat at a distance of 3 cm. from the outer border of the first rib. The second was given off from the lateral pectoral nerve and entered the arterial coat 3.5 cm. from the outer border of the first rib. The third, arising from the loop of communication between the lateral and medial pectoral nerves, entered the vessel wall 3 cm. from the outer border of the first rib. The fourth, which arose in a similar fashion to the third, was traced for a distance of 7.5 cm. along the vessel before it entered the arterial coat. These findings seem to show that reinforcements of sympathetic fibres from somatic nerves reach the artery sufficiently high to limit the area liable to aneurismal dilatation, to a comparatively short distance beyond the point of trauma.

### CONCLUSIONS

While the diagnosis of a pressure lesion at the cervico-brachial junction is usually simple, the causes of such pressure are so varied and obscure that in the present state of our knowledge it is not possible to forecast the exact cause in all cases. It can be said only that symptoms which are predominantly in the hand point to a hang-up of the lowest trunk of the brachial plexus on some abnormal structure, while more widespread symptoms such as pain in the region of the upper arm indicate clavicular pressure during retraction and abduction of the shoulder on an abnormal structure, most commonly a cervical rib.

Having decided on clinical grounds, radiographic evidence, and the failure of conservative treatment, that operation is indicated, the approach should be frankly exploratory through an adequate incision. To operate with no more purpose than to carry out a pre-conceived plan such as anterior scalenotomy is to invite failure.

### SUMMARY

- 1 The causes of pressure on the neuro-vascular bundle of the upper limb are many and varied. No one cause such as clavicular pressure can explain all cases.
- 2 Costo-clavicular pressure is not possible when there is a normal first rib and a normal thoracic outlet, but it is certainly a factor when the costo-clavicular interval is narrowed by the presence of a large cervical rib or an abnormal first thoracic rib. Clavicular pressure can act only during retraction and abduction, not in depression of the shoulder.
- 3 Temporary alterations in the radial pulse on movements of the shoulder in normal individuals are due to causes distal to the clavicle and have no relation to costo-clavicular pressure.
- 4 While irritation of sympathetic nerve fibres may explain the majority of cases of thrombosis, there are others in which clotting occurs in an aneurismal dilatation produced by pressure between the clavicle and the abnormal costal element. It is likely that the thrombosis occurs in an aneurism which has been present for some length of time. The cause of the aneurismal dilatation may be vaso-motor paralysis of a segment of the artery, ending distally at a point where a fresh intact leash of nerves is relayed to the vessel.
- 5 The importance of the scalenus anterior syndrome has been over-emphasised. If operative treatment is limited in all cases to anterior scalenotomy the results will be disappointing.
- 6 If operation is advised it should be performed without rigid and preconceived ideas, through an adequate incision, and with exploration wide enough to allow thorough investigation of the cause of pressure.

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# FATIGUE FRACTURES OF THE FIBULA

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In describing certain fractures of the fibula, sustained without violence, the writer (Burrows 1940) expressed the hope that further cases would be published so that something could be learnt of these uncommon fractures. Additional cases have now been described. The writer has encountered five other personal cases, and scrutiny of the literature has revealed at least one previous case (Detlefsen 1937). It seems fitting, therefore, to review the subject in detail. Fatigue fracture \* of this bone ranks in frequency after the metatarsus, the tibia, and perhaps the femur (Asal 1937, Richmond 1945). As a site for fatigue fracture the fibula has a special, though not unique, place in being a non-weight-bearing bone—a fact which emphasizes the importance of the stresses of muscular action rather than those of weight-bearing.

## FATIGUE FRACTURE OF THE LOWEST THIRD OF THE FIBULA

Detlefsen (1937) described an overloading fracture 6 cm above the lower end of the fibula which developed without injury in a compulsory state worker. He compared it with the fatigue fractures of inanimate materials in industry.

In 1940 Weaver and Francisco described the case of a student, aged twenty-two years, who had been carrying out running practice for several months when for no apparent reason he sustained what was almost certainly a fracture of the right fibula, 3 cm above its lower end. Five months later a similar condition developed in the neck of the left fibula. The authors regarded the lesions as "pseudo-fractures" and ascribed them to non-suppurative osteomyelitis.

Simultaneously and independently the present writer (Burrows 1940) described two cases of spontaneous fracture of the apparently normal fibula in its lowest third, developing with no history of injury but in association with much activity (cross-country running in one case). While recognising that two cases alone warranted speculation rather than conclusion he suggested an analogy with march fracture of a metatarsal bone. He compared the condition with other military fractures occurring without obvious violence, and indicated the desirability of recording further cases.

Detlefsen (1941) described fatigue fracture of the lowest third of the left fibula in a woman thirty-seven years of age whose work at a machine called for depression of a vibrating pedal with the left foot for eight hours daily. Ingersoll (1943) described fatigue fractures in the lowest two or three inches of the fibula of three patients—all boys, all aged nine years, and all beginners at ice-skating. In one case the fracture was bilateral.

In 1944 Hamilton and Finklestein described bilateral fatigue fracture of the lowest third of the fibula in a recently recruited infantryman who was undergoing training and subsequently suffered march fracture of the second metatarsal bone. The fibular fractures were described as march fractures. In another bilateral case recorded by Ronald (1945) the symptoms began during a cross-country run and changes developed in the right fibula about two weeks after those in the left.

Richmond (1945) described two unilateral cases in soldiers undergoing training. In one, the pain developed after a cross-country run. McPhee and Franklin (1946) recorded cases in a track runner and a basketball player.

\* *Spontaneous fractures* are fractures without material violence (*i.e.*, without acute trauma), and may occur in pathological bone or in seemingly normal bone. *Fatigue fractures* are spontaneous fractures of seemingly normal bone. They appear to result from a summation of stresses which singly are insufficient to produce fracture.

TABLE I—ANALYSIS OF PUBLISHED AND PERSONAL CASES OF FATIGUE FRACTURE OF THE FIBULA  
(*Doubtful cases in italics*)

Part of fibula affected	Author	Year	No. of pts.	Side	Age (Yrs.)	Sex	Occupation	Activities
(i) Lowest third	Grunert	1910	1	R	—	M	Grenadier recruit	Doubling
	Linny	1924	1	R and L	—	M	Infantry private	Cross-country running
	Detlefsen	1937	1	—	20	—	(Compulsory state service)	
	Weaver and Francisco	1940	1	R	22	M	Student	Running practice for Track team
	Burrows	1940	2	L R	61 17	I M	Parish worker Schoolboy	Much walking Cross country running
	Detlefsen	1941	1	L	37	I	Muster needlewoman	Depression of vibrating pedal
	Ingersoll	1943	3	R and L R L	9 9 9	M M M	Schoolboy Schoolboy Schoolboy	Beginner at ice skating Beginner at ice skating Beginner at ice skating
	Hamilton and Finklestein	1944	1	R and L	—	M	Infantry recruit	Training
	Richmond	1945	2	L L	— —	M M	Infantry NCO training Infantry soldier training	Cross country running Assault course etc
	Ronald	1945	1	L and R	—	M	(Not stated? airman)	Cross country running
	McPhee and Franklin	1946	2	R R	— —	M M	University athlete University athlete	Track running Basketball
	Burrows	1948	5	R R L R R	20 45 56 51 63	M F F F F	Medical student Nurse Housewife Housewife Housewife	Cross-country running Much on feet Household duties and walking Household duties
(ii) Upper-most third	Hopfengartner	1907	39	—	—	M	Infantry in first year	Jumping (25 cases)
	Dreist	1909	1	—	—	M	Fusilier in first year	Attacking from kneeling
	Grunert	1910	1	R	—	M	Grenadier recruit	Training
	Scherf	1933	9	4R 5L	— —	M M	Artillery recruits	Jumping exercises from double knees-bend
	Asal	1936	Many	2 bilateral	—	M	Artillerymen (mostly)	Jumping on and off limber for hours on end
	Asal	1937	12	Many bilateral	—	M	Artillerymen (mostly)	Gun exercises with much jumping on and off limber
	Wachsmuth	1937b	1	L and R	21	M	Infantry recruit	Training exercises
	Wachsmuth	1937a	Several	—	—	M	Infantry in training and artillerymen	Jumping knee bending squatting
	Detlefsen	1937	1	R	21	—	Compulsory state service	
	Weaver and Francisco	1940	1	L	22	M	Student	Running practice for track team
	McPhee and Franklin	1946	1	L	—	M	University athlete	Running
	Siemens	1942	1	L and R	16/12	M	(Infant)	Reputedly very lively
(iii) Middle third	Leveton	1946	1	L	19	M	Recruit	Training
	McPhee and Franklin	1946	1	L	—	M	University athlete	Running

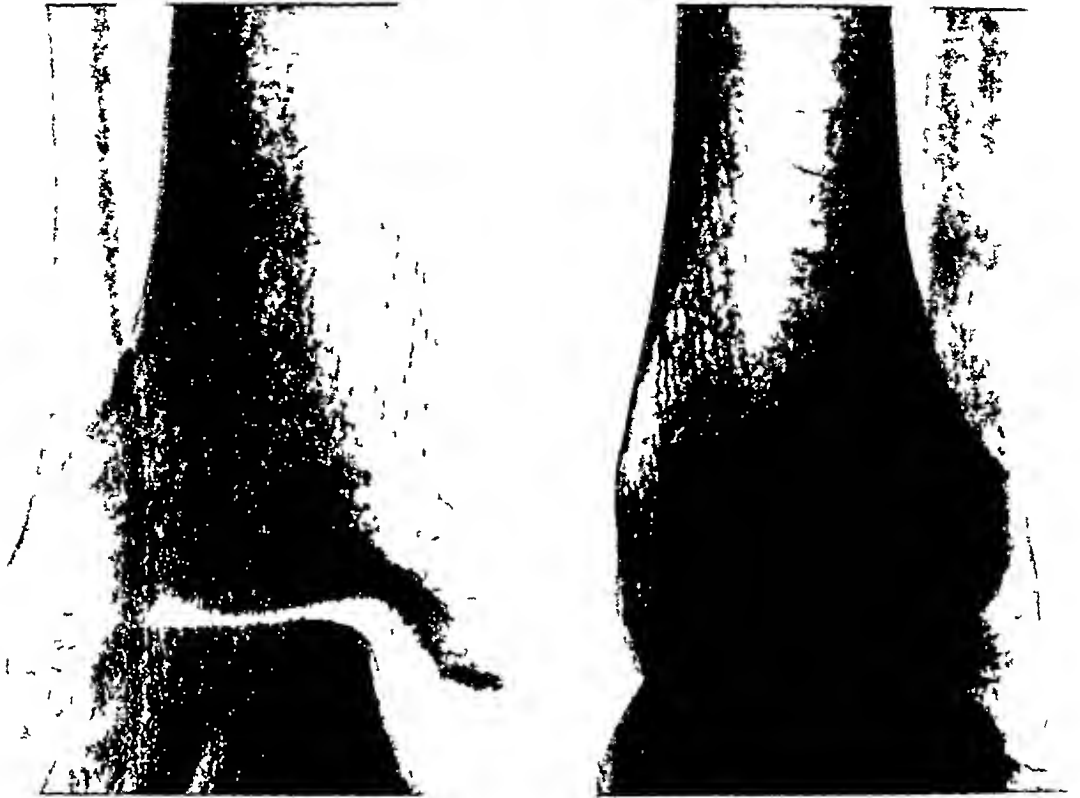


FIG 1

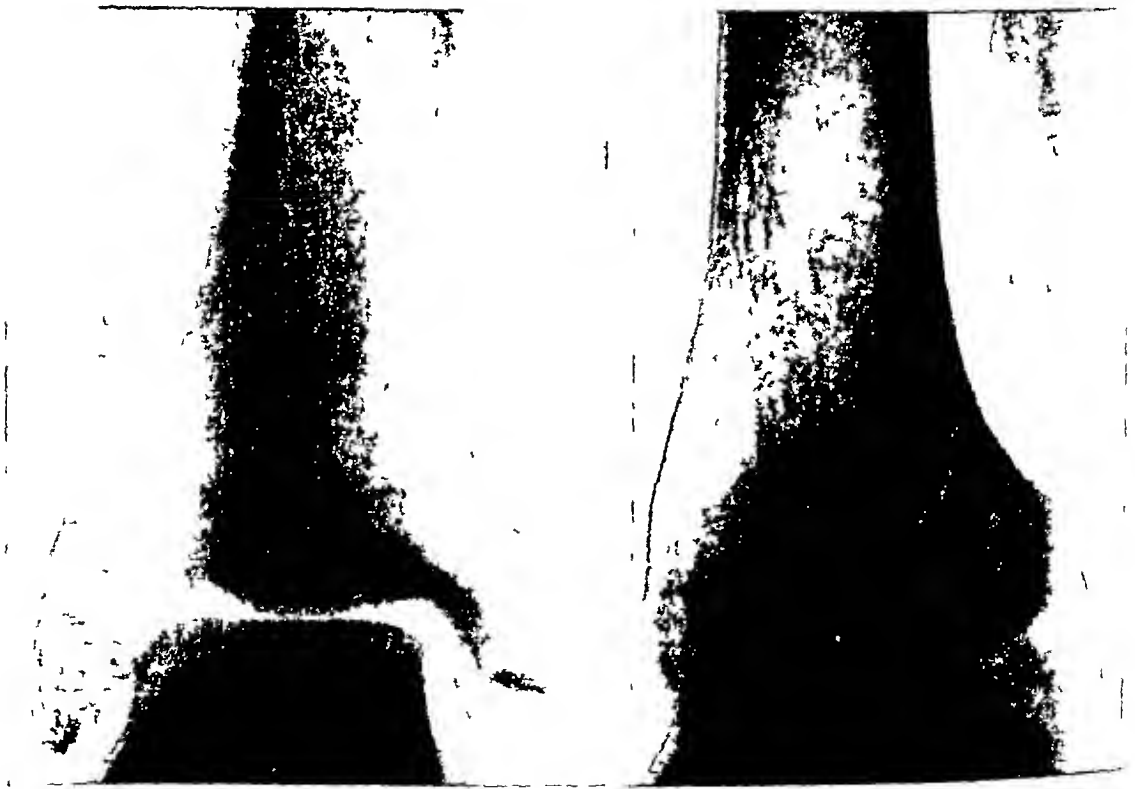


FIG 2

Case 1 Fig 1 shows the radiographic appearances twenty-three days after the first symptoms and sixteen days after the first acute symptoms. A band of slightly increased density and subperiosteal ossification is just discernible. A week before, no radiographic abnormality could be detected. Fig 2 shows the appearances five weeks later than those in Fig 1. Calcified callus is much increased but no fracture line is evident.

Association with strenuous running in at least five cases may throw new light on two examples of fibular fracture which were reported many years ago. Grunert (1910) reported a fracture at the junction of the lowest and middle thirds of the fibula in a recruit who complained of pain after running, but he ascribed it to forced supination. Finny (1924) told of a soldier who was running in an inter-regimental cross-country race and twisted his left foot inwards on a lump of earth, as he stumbled the other foot was twisted in a similar manner. He completed the remaining three miles of the race and finished twelfth out of a large field. Radiographs showed a fracture two inches above the lower end of each fibula.

### Further Personal Cases

Five additional cases of fatigue fracture of the fibula at this site are here reported.

**Case 1** Medical student, aged 20 years. Nine years before being seen he won a seven-mile inter-club cross country race in 40 mins. 44 secs. As he jogged back to the pavilion which was about a mile distant, the lower end of the right fibula became painful and the ankle felt stiff. After being supported with elastic adhesive strapping it improved each day and four days later with the ankle still strapped, a gentle three-mile run caused no discomfort. Two days before being seen he had taken part in an inter-university cross-country run of more than six miles. After running three and a half miles sudden pain at the same site made him stumble but not fall. There was no audible snap. He had to walk home covering three miles of frozen rough ground in about an hour. The strapping became tight and the painful area throbbed. Change of strapping and a hot bath brought relief but he was awakened at about 2 a.m. with much pain which was relieved by removal of the strapping. There was no further improvement. Pain increased on resuming activity after rest or moving the limb forwards against gravity. There had been no injury and the pain had preceded the stumble. On examination the fibula was tender over a length of about one and a half inches centred at a point of maximum tenderness two and a half inches above the tip of the lateral malleolus. No swelling was visible or palpable and there was no redness or increased skin temperature. Active and passive tarsal and ankle movements were full except that active dorsiflexion was limited at the right angle. Passive dorsiflexion alone gave slight pain at the site of tenderness. Similar pain was produced by jarring or by springing the tibia and fibula. Radiographs showed no bone abnormality even on close scrutiny with a lens but the clinical diagnosis of fatigue fracture of the lowest third of the fibula was made with confidence. Elastic adhesive strapping was applied from the metatarsal heads to the top of the calf with steady improvement in the pain. Seven days later there was still no radiographic change but seven days later when a slight hard swelling had appeared at the tender site further radiographs (Fig. 1) showed a band of slightly increased density about three sixteenths inch broad with very slight subperiosteal ossification situated two and a half inches above the tip of the lateral malleolus. By the end of the next three weeks the range of movement had returned fully the radiographic changes were substantially increased and the strapping was discarded. After yet another fortnight walking standing and running were painless though followed by throbbing movements were full and radiographs showed increased subperiosteal opacity but still no fracture line (Fig. 2). After another fortnight there were no symptoms or signs except slight local tenderness and bony swelling. These were still evident fifteen weeks after the onset when radiographs showed that the new bone was well organised and with some indication of a transverse, relatively clear band. Twenty-two weeks from the onset he was free of all symptoms and won the inter-hospitals three miles race in 16 mins. 3½ secs. A bone ridge was still palpable clinically and visible radiographically. At no time was wasting of the calf demonstrable. Control radiographs of the hand showed no evidence of porosis.

**Case 2** Nurse, aged 45 years, working in an old-fashioned nursing home who had not recently increased her activities or suffered any injury. One afternoon four weeks before examination pain and swelling developed suddenly in the region of the right lateral malleolus. Both were worse by day than by night. She managed her duties for two weeks and the swelling diminished gradually. On examination oedema and a slightly raised cutaneous temperature were found over the lower part of the right fibula which was tender at a level about one and a quarter inches above its lower end. Ankle and tarsal movements were full and painless. Radiographs (Fig. 3) showed a fracture of the fibula one and a half inches above the tip of the lateral malleolus. Displacement was minimal. In the antero-posterior view the fracture appeared transverse but the lateral view showed that it passed obliquely forwards and downwards for a quarter to half an inch. Scarcely any callus was visible. Strapping which had been applied to the foot ankle and calf was removed by the patient within a week because she had become quite comfortable. When seen again three and a half weeks after the first occasion and seven and a half weeks



from the onset she was quite comfortable and the oedema had disappeared but there was still slight tenderness and by then some bony swelling at the site of fracture. Further radiographs showed a fairly pronounced cuff of callus (Fig 4)



FIG 3



FIG 4

Case 2 Fig 3 shows the radiographic appearances at first examination, four weeks after the onset of symptoms. A small amount of ossified callus is present. Fig 4 shows the appearances three and a half weeks later than those in Fig 3 and seven and a half weeks after the onset of symptoms. Ossified callus has increased considerably.

Case 3 Housewife, aged 56 years, who was "on the go all the time" and "did everything" for a husband and four bachelor sons. She liked walking and five weeks before being seen she took an unnecessary walk of two miles in addition to ordinary activities. On rising next morning she had great difficulty in carrying on because of pain in the left ankle which soon became swollen, shiny, and hot but not red. The pain was relieved by rest but it was particularly severe when activity was first resumed. Walking was worse than standing. There had been no injury. Slight spontaneous improvement occurred slowly. The diagnoses of gout and thrombophlebitis had been made at different times. On examination, five weeks after the onset, diffuse pitting oedema of the left ankle region was found with tenderness just proximal to the lateral malleolus and with about ten degrees limitation of plantar flexion movement. The feet were supple but were flat both longitudinally and transversely. Radiographs showed a broad transverse fracture line one and a half inches above the tip of the lateral malleolus, without displacement and with little callus (Fig 5). Control radiographs of the hand showed no porosis. Elastic adhesive strapping was applied from the metatarsal heads to the upper calf for three weeks with improvement. The pain did not disappear completely nor did plantar flexion return fully for twenty-five weeks. Even then very slight local tenderness and bony swelling persisted. Further radiographs (Fig 6) taken nine months after the onset showed complete restoration of bone texture, the only indications of the old fracture site being a band of slightly increased density and very slight bony thickening.

Case 4 Housewife, aged 51 years—a very energetic woman. Besides caring for a husband and two children aged twenty-one years and thirteen years, she worked five hours a day as inspector in an engineering works—a sitting job which involved a brisk twenty minutes' walk each way over a rough country road. On getting out of bed thirteen days before being seen she found that the lower right fibular region was painful. She went to work but increasing pain during the afternoon drove her to her doctor who diagnosed "sepsis". She remained off work (but continued housework) and applied kaolin poultices for a week and then a crepe bandage without improvement. Walking was more painful than standing and rest from weight-bearing brought improvement. Nocturnal aching did not interfere with sleep. The pain was not aggravated on first resuming activity after rest. There had been no relevant injury. On examination



FIG 5

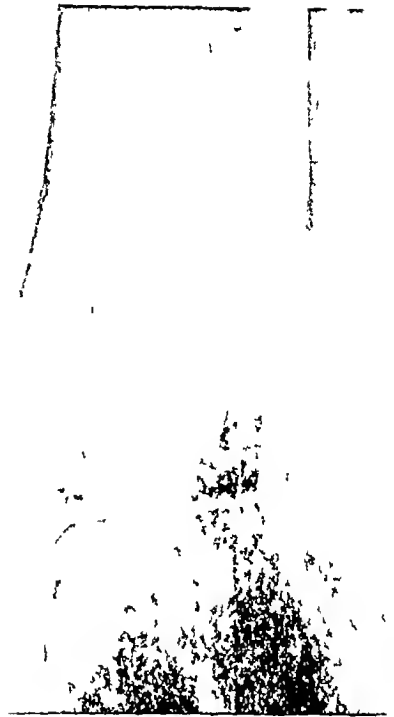


FIG 6

Case 3 Fig 5 shows the radiographic appearances five weeks after the onset. Though the fracture zone is distinct callus is scanty. Fig 6 shows the radiographic appearances nine months after the onset. The structure of the bone is fully restored but the site of fracture is still marked by a dense band.



FIG 7

Case 4 Radiographic appearances twenty-five days after first examination. Horizontal fracture one and a half inches above the tip of the lateral malleolus with substantial callus.

non-pitting oedema was found over the outer part of the right ankle region without redness or increased cutaneous temperature. Localised tenderness was elicited about one and a half inches above the tip of the lateral malleolus. Dorsiflexion and plantar flexion were about half the normal range, inversion and eversion about three-quarters. Moderate hallux valgus-rigidus was present. *Radiographs* showed an almost horizontal fracture, one and a half inches above the tip of the lateral malleolus with slight posterior displacement of the distal fragment. *Control radiographs* of the hand revealed no porosis. A plaster of Paris walking cast was worn for eleven days followed by elastic strapping. After twenty-five days' treatment there were still some pain, local tenderness, and swelling. The girth of the calf was diminished by a quarter of an inch. Movements were full and painless except that inversion caused pain at the fracture site. *Further radiographs* (Fig 7) showed substantial callus. Thereafter she had practically no discomfort, and returned to work nine days later. After another five days there was still a hard, slightly tender swelling on the fibula and still a quarter of an inch wasting of the calf, but movements were full and painless.

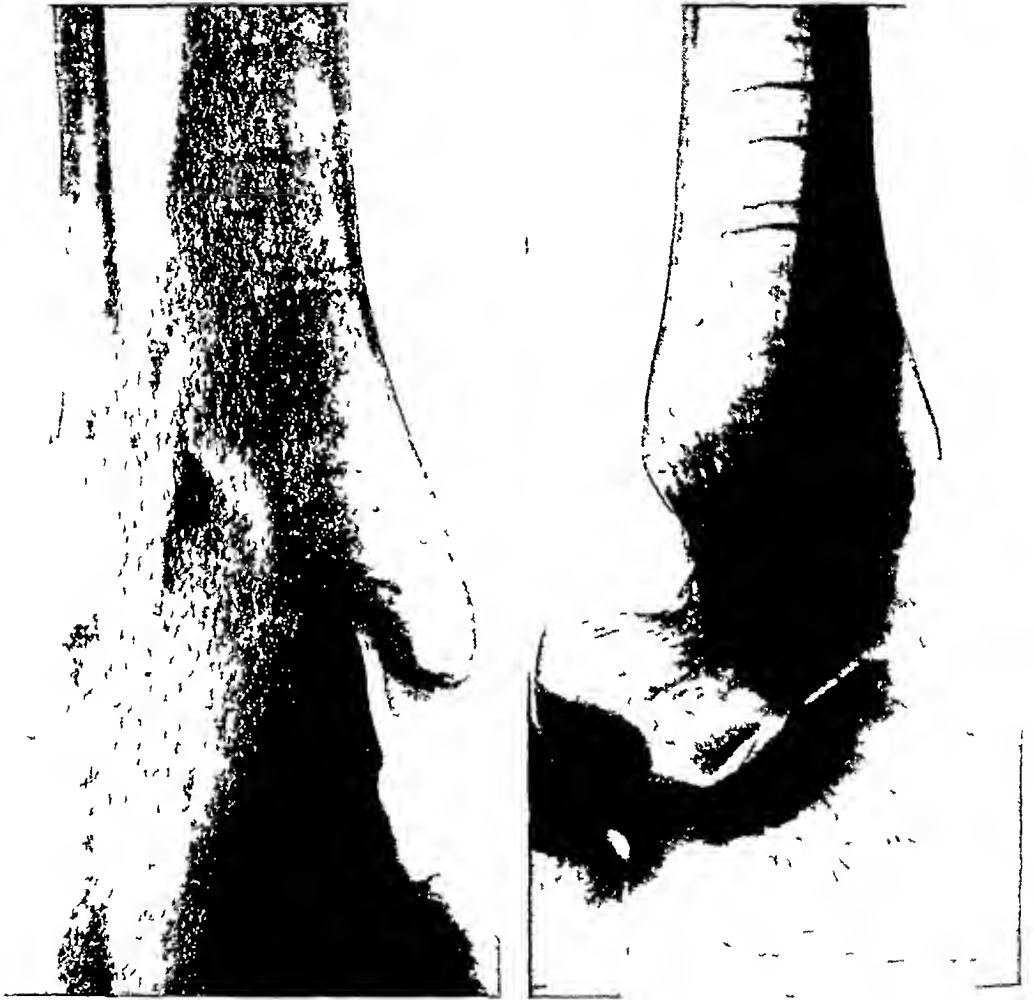


FIG 8

## Case 5 Radiographic appearances

**Case 5** Housewife, aged 63 years, with only a husband to look after but nevertheless on her feet almost all day. Twenty-four days before being seen she was walking about on household duties when she noticed severe pain in the outer side of the lower part of the right fibula. The pain, which drew attention to swelling, was aggravated by standing or walking, especially out-of-doors, and was improved by rest. There had been no injury. On examination the right fibula presented a bony hard, tender swelling one and a half inches from its lower end, with adjacent non-pitting oedema but with no redness or raised temperature. There was a full range of painless tarsal and ankle movement and no measurable wasting of the calf. *Radiographs* (Fig 8) showed an almost transverse fracture about one and a half inches above the tip of the lateral malleolus without displacement. A little calcified callus was present. There also appeared to be diminished density of all bones, the same being so on the left side but without fracture. *Control radiographs* of one hand (Fig 9) showed evidence of slight generalised porosis which, however,

was not considered to be of pathological degree. Elastic adhesive strapping was applied from the base of the toes to just below the knee. It was continued for five weeks by which time all pain, tenderness and oedema had subsided. The patient reported that twenty years earlier swelling of one foot had appeared spontaneously and without injury. It had lasted about one month and no radiographs had been taken. Radiographs now show evidence of a united fracture of the distal third of the second left metatarsal bone (Fig. 10).

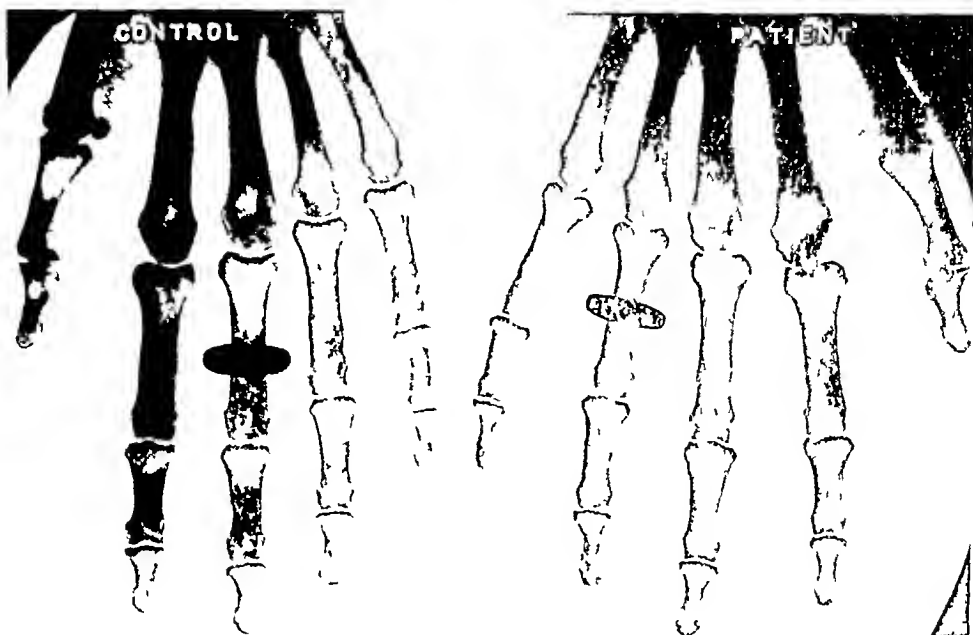


FIG. 9

Case 5. Control radiograph of hand. The patient's hand (which was taken simultaneously with that of a control subject on the same film) shows very slight relative porosis which if of pathological degree would negative the diagnosis of fatigue fracture.



FIG. 10

Case 5. Radiographic evidence of old fatigue fracture of the second left metatarsal bone of which a possible twenty-year-old history was given.

**Comment**—From this review, two groups of fatigue fracture of the lowest third of the fibula may be defined: 1) fractures in young male runners and skaters, 2) fractures in women of middle age or over, who have much to do on their feet. The example of the second group recorded by the writer (1940) was ascribed by Hartley (1943) to "spontaneous fracture due to age." But even if sixty-one be old, age is not a disease, and moreover there was a history of much activity and no obvious evidence of osteoporosis. The same is true of the cases here described, with the sole exception of the last which did show some generalised porosis, but apparently not of pathological degree so that there was little justification for the diagnosis of pathological fracture rather than that of fatigue fracture.

## Clinical Features

A study of published and personal cases has yielded some knowledge of the clinical features of fatigue fracture of the lowest third of the fibula

**Age, sex, side affected, and activities** of the patients are indicated in Table I (Section 1) The natural grouping into young male runners and less young active women has already been mentioned Four of twenty-one patients had bilateral fractures of the lowest third

**Site of fracture in the lowest third**—The fracture was one and a half inches above the tip of the lateral malleolus in the five women observed by the author, whereas it occurred at a higher level in each of the two male patients Study of other cases reported in the literature shows a similar distinction (Table II) It shows that most male patients (all the cross-country runners and skaters) suffered fractures two inches or more above the lateral malleolus, but that this was true of only one woman If the difference in level is significant it may depend

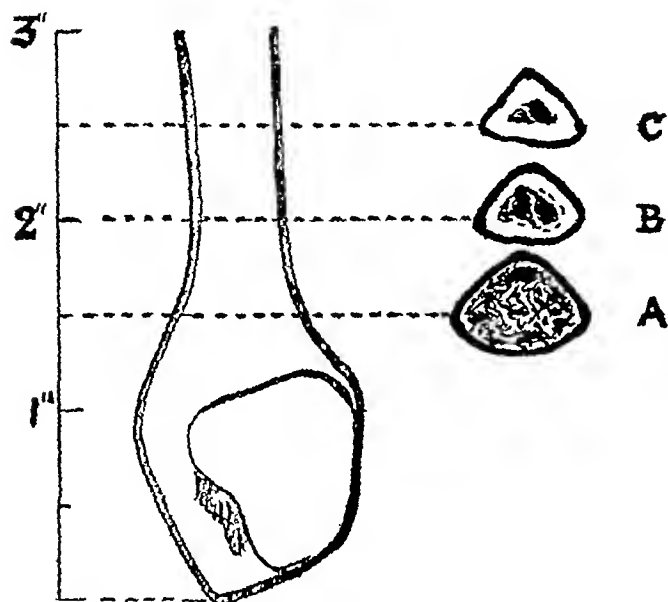


FIG 11

Cross sections of the adult fibula at various distances from the tip of the lateral malleolus A one and a half inches B two inches and C two and a half inches The change in character within the short distance of half an inch between A and B is striking

upon sex, age, or type of stress Let it suffice at present to record that elderly, hard-pressed women tended to have fractures one and a half inches above the tip of the lateral malleolus through mainly cancellous bone at a level immediately below the interosseus ligament, whereas young male runners and skaters tended to have fractures at a higher level where the bone is slender but largely cortical In this region the character of the bone, both as to thickness and composition, changes very rapidly with level (Fig 11)

**Symptoms**—There has always been much activity involving repetition of the same resisted movement—walking, running, skating, and in one instance depression of a vibrating pedal Usually the symptoms started during such activity but two patients here recorded first noticed pain on

rising one morning As a rule, customary activities are continued with difficulty for some days or weeks

*The first complaint* has been *pain* and in the case of two patients a sensation of “stiffness” Occasionally the onset has been sudden, making one patient stumble and another fall The site is described as the ankle, the lateral side of the ankle, the lateral malleolus, above the malleolus, or the outer part of the leg There is relatively little information in the literature as to the characters of the pain, but in general it seems to be improved though not necessarily abolished by rest and to be increased by weight-bearing, especially weight-bearing with movement It is sometimes worse on first resuming activity after a period of rest As in fatigue fractures elsewhere, there is not only an absence of violence but also of any audible snap, so that no suspicion of fracture ever occurs to the patient

**Signs**—*Localised tenderness* is usually present, but its absence was recorded specifically in three cases which were seen from three to eighteen days after the onset of symptoms (Hamilton and Finklestein 1944, Ingersoll 1943) *Localised swelling* was reported in all cases but five

TABLE II

Author	DISTANCE OF LATIGUI FRACTURE OF THE LOWEST THIRD OF THE FIBULA FROM THE TIP OF THE ANTERIOR MALLEOLUS		
	Male	Female	Sex not stated
Grumert (1910)	2 in		
Linna (1924)	2 in		
Detlefsen (1937 and 1941)		3 fingers breadth	About 6 cm
Weaver and Francisco (1940)	3 cm		
Burrows (1940 and 1948)	3½ in 2½ in	1½ in 1½ in 1½ in 1½ in 1½ in	
Ingersoll (1943) (Patients not given)	2½ in 2½ in 3 in		
Hamilton and Finklestein (1944)	About 1½ in		
Richmond (1945)	2 in 2 in		
Ronald (1945)	2½ in		
McPhee and Franklin (1946)	2 in One-third length of fibula		

At first there is pitting or non-pitting oedema. This diminishes, and about three weeks from the onset of symptoms, a hard swelling of the tender area of the fibula becomes palpable. Slight redness has been reported twice (Hamilton and Finklestein 1944, McPhee and Franklin 1946). Increased local cutaneous temperature of slight degree has been recorded four times (McPhee and Franklin 1946, Burrows 1948). Limp was mentioned exceptionally. Wasting of the calf was found in one only of the writer's patients, the girth being diminished by half an inch. Ankle and tarsal movements are often undiminished. Most writers have failed to comment on movement but its freedom was remarked in six cases, from seven days to five weeks after the onset (Burrows 1940 and 1948, Detlefsen 1941, Hamilton and Finklestein 1944). Three patients in this series showed slight limitation of ankle movement but in no other known cases has limitation been recorded.

### Radiographic Examination

During the first fifteen days or more no radiographic change may be discernible. On the other hand a fracture line may be evident after a week, sometimes none appears till the end of the second or third week. At first it is difficult to see, and even after four weeks it may be recognised only with the aid of a lens. A band of rarefaction may be seen at twelve to eighteen weeks. Callus has been observed in a child as early as the eighth day. In adults it appears during the third week, steadily consolidating and becoming organised at twelve to sixteen weeks when it forms a spindle-like thickening crossed by a less dense stripe at the site of fracture. At forty-seven weeks it may still be just possible to distinguish thickening. A dense band is often the first indication of the fracture site and almost the last to disappear (See Figs 1 and 6). The plane of fracture is almost horizontal, slight deviations from this are not always in the same direction so that little can be concluded about the fracturing stresses.

### Diagnosis

Since the condition is unfamiliar, and therefore unsuspected, it seems probable that it is often overlooked altogether. The freedom of joint movement and the site of tenderness help to distinguish it from sprains, but the absence of tenderness may be misleading. Radiographic examination must be the chief safeguard. In early suspected cases, if no abnormality is revealed with the aid of a lens the films should be repeated after three weeks. Competent interpretation is no less important than good radiography. Such diagnoses as osteomyelitis, tuberculosis, congenital syphilis, sarcoma and myositis ossificans have been made, and such errors may prove far more damaging than failure to recognise any lesion at all.

### Treatment and Results

Provided that the exciting activity is discontinued, normal pursuits may be allowed with the comfort afforded by elastic adhesive bandage from the metatarsal heads to the upper calf. Physiotherapy is not required. With such treatment pain diminishes or disappears within a week, but tenderness may remain for as long as eight to sixteen weeks. Bone thickening persists still longer. It is difficult to be certain when the promoting activity may be resumed with safety, but too early resumption may cause recurrence of symptoms, or occasionally fatigue fracture of the opposite fibula or another bone.

### FATIGUE FRACTURES IN THE UPPERMOST THIRD

Weaver and Francisco (1940) reported what were described as "pseudo-fractures," first in the lowest third of one fibula and then in the uppermost third of the other, in a student, but most recorded fractures at this higher level have been in soldiers. Hopfengartner (1907) recorded military fractures of the uppermost third of the fibula in infantrymen during their first year of service. In twelve of the eighteen cases pain was first produced by jumping. The regimental records included twenty-one other cases, thirteen of them ascribed to jumping. Dreist (1909) reported fractures of the fibula at about the junction of the uppermost and middle thirds in two fusiliers during their first year of service. One sustained his fracture in landing from a vault and must be excluded because of the obvious trauma. The other noticed gradually increasing cramp-like pain during practice in attacking from the kneeling position. Radiography revealed an incomplete fracture which was attributed to strain from the nature of the exercise. Fractures in recruits reported by Grunert (1910) included one situated seven centimetres below the head of the fibula, sustained without apparent cause but interpreted as a torsion fracture. Scherf (1933) described fracture of the fibula at the junction of its uppermost and middle thirds, without direct injury and with little or no displacement, in nine artillery recruits who were required to carry out jumping exercises from a double-knees-bend position for about five minutes several times daily. Pain in the calf would start suddenly during the exercise. The author was uncertain whether the lesions were to be regarded as fractures or "transformation zones" (*umbauzonen*). Wachsmuth (1937a) emphasised jumping and repeated double-knee-bending as exhausting the "working efficiency of bone," the commonest effect being fracture of the fibula, usually at the junction of middle and uppermost thirds. Tibial march fracture, affecting mostly infantrymen and confined to the training period, might be accompanied by a corresponding fracture of the fibula. In the records of the German Army hospitals covering the year 1935-36, Asal (1936, 1937) found 590 cases ascribable to "overloading injury" and distributed as follows: metatarsals 488, tibia 70, femoral shaft 7, femoral neck 6, fibula 12, os calcis 4, and pelvis 3. The fibular fractures, mostly affecting the junction of middle and uppermost third, occurred mainly in artillerymen and were ascribed to intensive gun exercises, particularly jumping on and off the limber over long periods. Wachsmuth also saw several such cases. Detlefsen (1937) described a case in a compulsory industrial worker. McPhee and Franklin (1946)

recorded one in a middle-distance runner. The frequent association with jumping is most striking. As the metatarsal fracture is the typical "march fracture," and the low fibular fracture is perhaps a running fracture, so the high fibular fracture appears to be typically a jump fracture.

It is interesting to compare fractures in the uppermost third of the fibula among infantry and artillery recruits with another series of fractures at the same site which constituted one of two typical leg injuries at a parachute school (Lord and Coutts 1944). These followed either parachute landings or platform jumps of four to six feet (Lord 1945). Pain was slight and patients often reported only after a delay of several days. Watson-Jones (1945) informed the writer that fifty-six fractures and dislocations sustained by a group of parachutists under training included "eleven cases in which a crack in the upper shaft of the fibula was suspected, or a fatigue fracture developed subsequently."

Former cases in artillery recruits and infantrymen, and more recent cases in parachutists, may be regarded as *either* 1) traumatic fractures caused by jumps but often masked by painlessness *or* 2) fatigue fractures, *or* 3) a combination of the two. Andreasen (1946) told the writer that the incidence of fracture of the fibula in its uppermost third amongst Indian parachute troops varied at different stages of their training but not in such a way as to suggest that fatigue was a material influence. Until further knowledge is available we cannot doubt the current view that high fibular fractures in infantry and artillery recruits are exclusively fatigue fractures, and that parachute fractures are exclusively traumatic fractures, but nevertheless the resemblance between these groups which each occur in young men undergoing severe training cannot be ignored, and it may be that trauma and fatigue both play a part in each group. A link would thus be forged between traumatic fracture due to a single adequate stress (abnormal *stress*), and fatigue fracture due to a summation of minimal stresses (abnormal *incidence*)—an interpretation which might be written thus:

	Stress	Incidence of stress
FATIGUE FRACTURE ( <i>e g.</i> , lowest third of fibula)	Minimal	+++++ etc
RECRUITS' FRACTURE OFTEN ASSOCIATED WITH JUMPING (uppermost third of fibula)	+	++++ etc
PARACHUTE SCHOOL FRACTURE (uppermost third of fibula)	++	+
TRAUMATIC FRACTURE	+++	Once

#### FATIGUE FRACTURE OF THE MIDDLE OF THE FIBULA

Siemens (1942) observed condensation and disintegration of bone structure in the middle of each fibula of a healthy boy aged sixteen months who complained of pain in the left leg when tired, and who limped. The right fibula showed periosteal new bone formation. Though the child was very lively the diagnosis of bilateral fatigue fracture of the fibula must, at this age, be accepted with reserve. Leveton (1946) described a fatigue fracture slightly above the middle of one fibula in a recruit aged nineteen years, and McPhee and Franklin (1946) reported a similar fracture just below the middle of the bone in a runner.

#### MULTIPLE FRACTURES

Multiple fractures naturally suggest general bone disease, which would exclude a diagnosis of fatigue fracture. The suspicion may prove false, multiple fractures sometimes occur without evident bone disease and they present all the typical characteristics of fatigue fractures and none of those of pathological fractures.



**Fractures of both fibulae** (at the same level or at different levels)—Bilateral low and high fatigue fractures have been mentioned. Low fracture of one fibula has been followed by high fracture of the other (Weaver and Francisco 1940)

**Fractures of fibula and metatarsal**—An infantry recruit, with bilateral low fatigue fracture of the fibula, later suffered a metatarsal march fracture (Hamilton and Finklestein 1944). Fatigue fracture of the third metatarsal bone in an infantry soldier under training was followed by a low fatigue fracture of the corresponding fibula (Richmond 1945) \*

Except in their multiplicity these fractures differ in no respect from typical fatigue fractures. It is possible that although no pathological cause has been found there may be predisposition in some individuals. Poor neuro-muscular co-ordination may play a part, as suggested by the observation of non-commissioned officers that recruits who developed such fractures had been awkward from the first (Wachsmuth 1937b). Moreover, Case 5 of this series shows that otherwise typical fatigue fractures at multiple sites (fibula and metatarsal) may in fact be associated with slight non-pathological osteoporosis.

\* Wachsmuth (1937b) mentioned an infantry recruit with fractures of one tibia and fibula between middle and uppermost thirds who was found to have an old united high fracture of each fibula. It is possible however that the recent fractures were traumatic. High fracture of the fibula sometimes complicates fatigue fracture of the corresponding tibia but it is possible that the fibular fracture is a traumatic complication of displacement of the tibial fracture, as in a case of Hartley (1942).

### SUMMARY

1 A hope expressed in 1940, that further cases of spontaneous fracture of the lowest third of the apparently normal fibula would be described, has been fulfilled. The literature is here reviewed. Five further personal cases are added.

2 The clinical and radiographic features, diagnosis, treatment and results are considered in the light of the information so far available. Special note is made of misleading freedom of ankle and tarsal movements and the occasional absence of tenderness.

3 It is established that fractures of the lowest third occur particularly in two groups of subjects: 1) young male runners and skaters, 2) active and hard-pressed women of middle age and over.

4 In male runners and skaters the fracture usually occurs through slender, mainly cortical bone, two inches or more above the tip of the lateral malleolus; in middle-aged women the fracture is usually distal to the interosseous ligament through thicker, mainly cancellous bone, one and a half inches from the tip of the lateral malleolus.

5 The most convenient name for both groups of fractures in the lowest third is *low fatigue fracture of the fibula*.

6 A review of the literature of fatigue fracture of the uppermost third of the fibula shows that it is very often precipitated by jumping. The most convenient name for it is *high fatigue fracture of the fibula*.

7 Like all clinical classifications this distinction between low and high fractures has exceptions (a low fracture of one fibula in a runner was followed later by a high fracture of the other, most military fractures were high, but a few may have occurred at other levels).

8 Fatigue fracture of the fibula, high or low, may be bilateral.

9 A fracture similarly situated to the high fatigue fracture of the fibula has been frequent in parachute schools. It is a speculative possibility that military and parachutist fractures of the upper third of the fibula indicate the link between true fatigue fractures (as exemplified by march fractures with minimal trauma often repeated) and purely traumatic fractures (with adequate trauma applied once only).

Thanks are due to Major Lord U S A M C, the late W Rowley Bristow, Professor A I Andreasen and Sir Reginald Watson-Jones for information given and to Dr W R Bett and the Librarian of the Royal Society of Medicine for their help with the literature. Case 3 was referred to me by my colleague, Mr W D Coltart.

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# THE MANAGEMENT OF ACUTE CIRCULATORY FAILURE IN AN INJURED LIMB

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Sudden arrest of the circulation in a limb is a catastrophe of particular interest to the orthopaedic surgeon because, apart from embolism and arterial disease, this emergency is almost confined to the vascular complications of fractures and dislocations. Crushing injuries of a limb, and accidents after the use and abuse of tourniquets are rare.

The fractures in which the circulation is most in peril are those of the lower end of the humerus, the upper parts of both bones of the forearm, the shaft and lower end of the femur, and the upper two-thirds of the leg bones. Actual gangrene complicating fractures in civil life occurs with greatest frequency when both anterior and posterior tibial arteries are injured as the result of high fracture of the tibial shaft, but arterial injury as such is found most



FIG 1

Supracondylar fracture lower end of humerus in a child of eight years with loss of radial pulse but no ischaemia of hand or forearm. There was no nerve lesion.

often in association with the much more common supracondylar fracture of the lower end of the humerus (Fig 1). The combination of fracture with vascular obstruction is nearly always the result of severe injury, and the dice are loaded against the surgeon who must work upon the badly damaged ischaemic limb of a patient with little reserve of strength. Yet, surgical treatment must be prompt and radical, for acute arterial occlusion carries real danger to life as well as to the limb itself.

## PRE-OPERATIVE INVESTIGATION OF TRAUMATIC ISCHAEMIA

**Diagnosis**—It is unhappily true that complete arrest of the arterial circulation of an injured limb is seldom recognised until too late. Moreover, even when the condition is diagnosed early enough for intervention to be useful, effective action is too often delayed by an attitude of wishful thinking. To be sure, the clinical features of acute ischaemia are usually plain and striking enough to call for immediate action. The mnemonic list of "pain, pallor, paralysis, and pulselessness" is perhaps an over-simplification, but it needs little elaboration.

All four are usually present in greater or less degree. *Pain* is perhaps the least constant. It may sometimes be absent, and it may vary from unpleasant numbness to real agony, but any pain, severe or slight, in the distal extremity of an injured limb must call for assessment of the circulation. *Pallor* is only one of a series of colour changes which may later pass from cadaveric grey-white through stages of irregular cyanosis to the black of frank gangrene. *Pallor* is, however, the first change and therefore the most important.



FIG 2

Closed fracture shaft of right tibia in a man aged twenty-four years. Arteriogram shows occlusion of both tibial vessels almost to the popliteal bifurcation which proved to be due to contusion at level of fracture with thrombosis. Gangrene occurred. Below-knee amputation was successfully performed after lumbar sympathectomy.



FIG 3

Closed fracture shaft of left femur in a man aged twenty-nine years with occlusion of superficial femoral artery by compression against the roof of Hunter's canal by a large haematoma. Signs of ischaemia developed seventeen hours after injury when the systolic blood pressure was 70 mm. The patient died.

*Paralysis*, both motor and sensory, takes a short while to be established and may be confused with the effects of nerve injury, but *absence of the distal pulses* is immediate and invariable. It is a sign more difficult to elicit in the lower limb than in the upper limb. Moreover absent pulses may not of necessity signify inadequate limb circulation. But the fact remains that the distal pulses must be sought, and that their absence may not be discounted lightly in any injured limb.

Despite some variability, it is remarkable how constant these signs are, and there is seldom any real doubt as to the adequacy of blood supply to a hand or foot. The *site* of

arterial block is usually indicated fairly clearly by the site of the fracture. The precise level can be determined by examination with an oscillometer or, at the time of operation, by arteriography. If there is doubt, it is usually true that the upper limit of block is a good deal higher than the surgeon is inclined to expect (Fig. 2).

**Pathology**—Apart from complete or incomplete division due to laceration by the fragments of a fracture, the arteries of an injured limb may sustain a variety of lesions in continuity. The most important are compression, intra-mural rupture, and contusion. Complete rupture

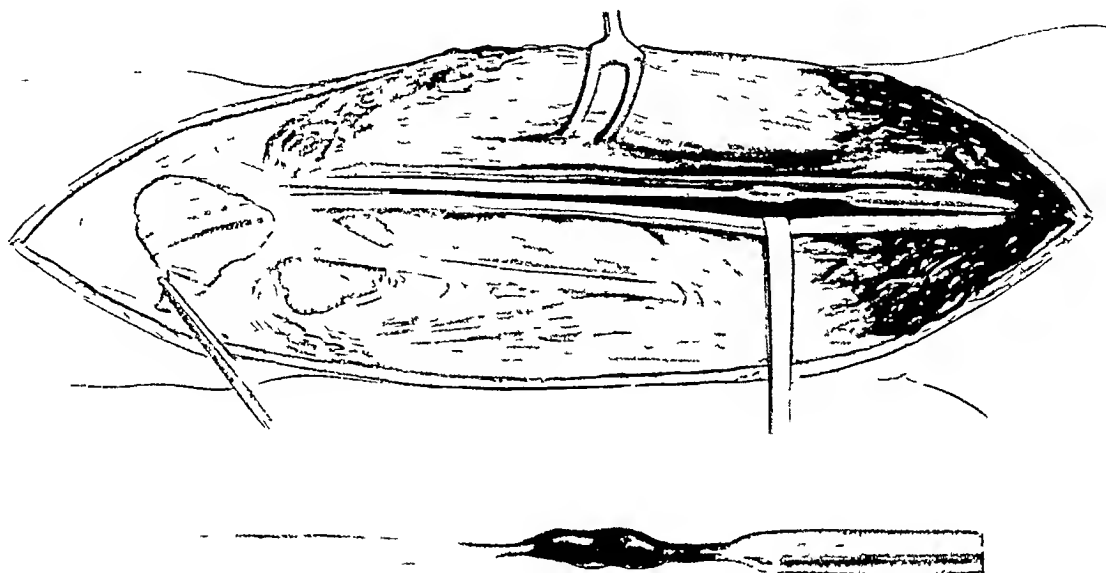


FIG. 4

Intra mural rupture of the brachial artery in a man aged forty-five years as seen at operation six hours after injury due to crushing by machinery. The lesion was accompanied by widespread arterial spasm which relaxed after excision of the damaged portion of the artery.

can follow traction injuries and has occurred in this way at the upper end of the popliteal artery following hyperextension of the knee (Wakeley and Reid 1932), but any form of rupture which produces an arterial haematoma or false aneurysm is extremely rare in civilian injuries.

*Compression* may be due to simple stretching across a displaced fragment, or to actual incarceration of the vessel between two fragments of a fracture. Very seldom, far more seldom than is often taught, the compressing agent may be a haematoma under tight deep fascia, but it will be clear that a haematoma with sufficient tension to occlude a main artery must have been formed when the arterial pressure was considerably higher than at the time of compression. Such occlusion by the pressure of a haematoma can occur therefore only some time after the injury, in a patient whose fallen blood pressure indicates even more grave problems than those of limb ischaemia (Fig. 3).

*Intra-mural rupture* (Figs. 4 and 5), the outer coat of the vessel being intact, occurs in traction injuries and crushing injuries. It is, of course, the usual result of ligation in continuity. *Contusion*, the commonest injury, may be severe or slight, but either degree can arrest the blood stream immediately by arterial spasm (Fig. 6) or later by thrombosis of the contused segment (Fig. 7).

*Traumatic arterial spasm* may accompany any form of arterial injury and produce wide spread block which magnifies the effect of mechanical obstruction. It may produce extensive

occlusion of an artery which shows no evidence of damage to the naked eye and which, indeed, may have received no more than a "near miss." Nevertheless conduction of blood may cease, just as conduction of nerve-impulses may cease in injuries which have produced no apparent damage to the nerve trunk. The cause, nature, and propagation of spasm are obscure, but it must be emphasised that ischaemia from spasm of an apparently undamaged artery is clinically indistinguishable from that due to mechanical obstruction, and that spasm and mechanical obstruction are usually present together. There is nothing essentially benign in traumatic arterial spasm, and to hope that an ischaemic limb is suffering "only" from spasm which "will probably relax" is to court disaster.



FIG 5

Arteriogram eight weeks after intra-mural rupture of the brachial artery at its extreme upper end due to forced mobilisation of the stiff shoulder of a man aged thirty-three years. There was a history of immediate pallor and paralysis of the limb. Recovery of paralysis was very incomplete and there was still anaesthesia of the hand.

**Investigation of a case of traumatic ischaemia**—However clear his idea of the pathology may be, the surgeon still needs all possible information before proceeding to treatment. Examination of the limb *and of the patient* must be complete. He must know the blood-pressure, the haemoglobin content of the blood, the points at which pulses are present and those at which they are not. Complete radiographic study of the bone injury is essential. Oscillometry, skin thermometry and even the taking of muscle temperatures (Adrian and Watts, 1923) may give useful help. The coagulation time should be known in case an anti-coagulant may be needed later. Treatment is urgent, but not so urgent that investigation can be scamped.

## TREATMENT OF TRAUMATIC ISCHAEMIA

**Principles of treatment**—There are four principles of treatment, the first two being applicable to every case

- 1) Removal of any possible external pressure,
- 2) Restoration of the patient's general condition

If these measures fail to relieve the circulation in the injured limb, and they usually do fail, the surgeon must proceed to

- 3) Operative exposure of the site of obstruction, with appropriate action, followed by
- 4) Post-operative management which is perhaps no less important than the operation itself

**Pre-operative measures**—The removal of any possible external pressure means that all encircling bandages and plaster casts must be removed and all traction apparatus relaxed, even if the dressings and extensions do not appear to be tight. The limb should be placed in the most comfortable position, slung on a Thomas splint, or simply supported on pillows, while general treatment is pursued. An intravenous saline drip infusion, or in the case of

lower limb injuries in adults a blood transfusion, is usually required. This is particularly true because if operative intervention becomes necessary the one thing that must never happen is a fall of blood-pressure during or immediately after operation. An alarmed and urgent call from the anaesthetist for blood transfusion at the end of the operation usually implies in itself that the outlook for recovery of the limb is poor.

**The operation**—Good general anaesthesia is essential. The theoretical advantages of spinal analgesia in ischaemia of the lower limb are usually outweighed by the dangers. A case can be stated for local anaesthesia, but not a very convincing one.

As soon as anaesthesia is induced, one and only one attempt should be made to reduce the fracture by manipulation. Manipulation may release a trapped artery and therefore lead to full restoration of the circulation and occasionally to return of the distal pulse, but it is more likely to improve the circulation, perhaps to a safe level, by relieving pressure on collateral vessels (Figs

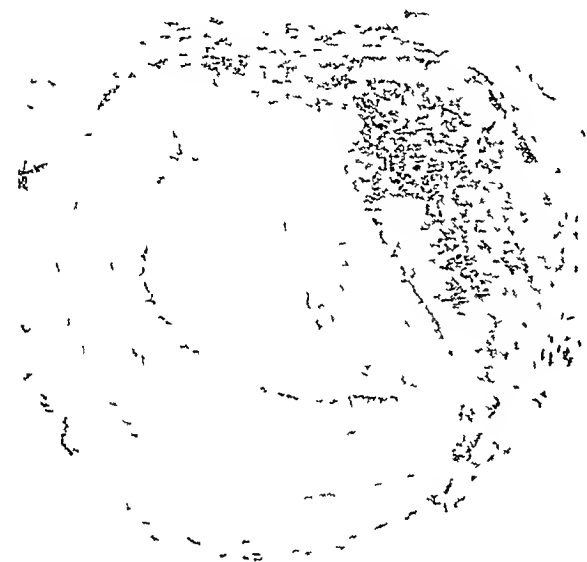


FIG 6

Contusion of brachial artery with haematoma of the wall but no thrombosis due to supracondylar fracture of humerus in a boy aged seven years. The widespread arterial spasm relaxed after excision of the contused portion. (Reproduced by kind permission from the British Journal of Surgery 1940 28, 252)

8 and 9) It must be remembered, however, that repeated manipulation of displaced fractures is more likely to cause arterial injury than to remedy it. Accordingly, no more than one attempt should be made. No time should be wasted in attempting mechanical reduction or applying skeletal traction, and if one manipulation fails to improve the circulation open operation is at once indicated.

I believe it is wise first to expose part of the main artery a short distance above the obstruction, to pass a loose rubber sling under it in case quick control should be needed, and then to perform an arteriogram. The technique of arteriography is described by Learmonth (1944). The contrast medium should be a diodone preparation, my own preference being for "Pyelosil" (Glaxo) in 50 per cent solution for adults, and in 35 per cent solution for the smaller arteries of children, which can be entered only by needles too fine to pass the

more viscous 50 per cent solution. The picture so obtained may give great help in deciding the future plan of the operation.

The next step is usually to make a generous exposure of the centre of occlusion unless such exploration is clearly too late, or cannot be performed without damaging collateral vessels. The decision as to whether or not to explore, calls for experienced judgment, but it may be stated as a general guide that little good can come from attempts to relieve total ischaemia of twelve hours' standing, and that even this is a generous estimate. Furthermore, relief of long-standing ischaemia is not always desirable. I have seen restoration of the circulation after twenty-four hours' obstruction kill the patient by flooding his general circulation with the products of tissue damage in the infarcted limb. My colleague A. N. Guthkelch (1947) has seen severe renal changes after successful release of no more than a twelve-hour block of the common femoral artery.

The time factor is of particular importance in the case of tourniquet accidents. It is to be regretted that, in the present state of our knowledge, the best advice that can be given is that a tourniquet which has occluded a thigh for six or more hours should not be removed at all, but should be amputated with the limb. It is to be hoped that work now being undertaken will lead to a happier solution to this grave problem.

The danger of damaging the collateral circulation arises particularly in obstructions of the upper parts of *both* anterior and posterior tibial vessels. Obstructions at this level are seldom amenable to direct surgical relief, and the anatomy of the collateral vessels is such that it is doubtful whether these vessels should ever be explored for acute traumatic occlusion. Here the value of an arteriogram is manifest (Fig. 2). Other things being equal, it may be wise to explore a blocked popliteal artery, but if radiographs show that the block is at a lower level the surgeon will be wise to hold his hand.

**Treatment of the damaged artery**—When there is no contra-indication, the occluded vessel is released and widely exposed. Repairable lesions should be repaired. Lateral suture of a torn artery by the Carrel (1907) technique, though seldom possible, may save an important



FIG. 7

Contusion with thrombosis in the popliteal artery of a man aged nineteen years who sustained a hyperextension injury of the knee joint at football two months before this arteriogram was made. Despite rich collateral circulation ischaemia persisted and produced classical contracture of the calf muscles.



channel and should not be followed by thrombosis even if anticoagulants are not employed. On the other hand end-to-end suture of a complete tear, as distinct from an incised wound, is never practicable.

Irreparable damage is a more common finding. The badly contused or irregularly lacerated vessel, or the artery which shows evidence of intra-mural rupture, should be treated by resection of the damaged portion, as advocated by Makins (1919) nearly thirty years ago. This much debated operation of *arterectomy* can do no harm in injuries of this nature, and will at least prevent spreading thrombosis and secondary haemorrhage which is more than can be said for ligation in continuity, an operation which should never be performed.

**Treatment of arterial spasm**—The artery which is found to be intact and apparently undamaged, but tightly occluded by widespread spasm, presents a difficult problem. All possible conservative measures for the relief of spasm should first be attempted. Wide mobilisation of the vessel has had success. If it fails, procain should be injected around the vessel and even into the lumen. The other limbs should be heated by immersion in hot water. Arterectomy should not be considered unless there is a visible local lesion. Above all, arterectomy is to be avoided if the vessel is in fact transmitting any blood.

Though no one doubts the wisdom of arterectomy for irreparable local lesions, there is much dispute as to whether the procedure is ever indicated for spasm alone. There are no reported cases in which arterectomy has relieved spasm of more than twelve hours' duration, but earlier operations (within seven hours of injury) have caused, or have at least been followed by, striking relief of spasm and cure of ischaemia (Griffiths 1940). Whether or not a reflex arc is broken, and whether or not the trans-section and release of smooth muscle influences the relaxation, early arterectomy has not only prevented spreading thrombosis or embolism from the site of damage, but has apparently also relieved spasm. Arterectomy in the adult limb does, however, tend to be followed by unpleasant and persistent symptoms



FIG 10

Arteriogram four and a half months after arterectomy of a damaged brachial artery in a man aged twenty-five years. Despite free collateral circulation through the profunda and other vessels, the hand remained partly anaesthetic. The proximal stump of the brachial artery is indicated at A.

such as digital anaesthesia or intermittent muscle cramp, and the conclusion must be drawn that the procedure should be reserved for vessels irreparably damaged, and vessels which are certainly empty and will never again transmit blood. In this way, at least no harm will be done. There is some hope, too, that further experimental work with cannulation or vein grafting may result in the development of a technique by which arterectomy can be followed by restoration of the channel (Mustard 1945, 1946).

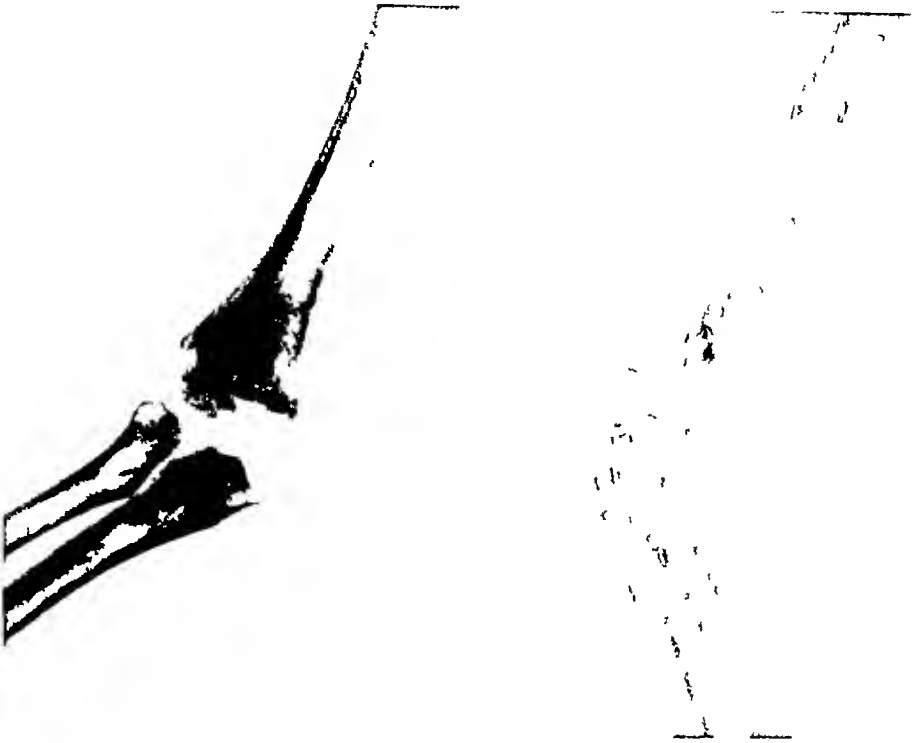


FIG 8

Supracondylar fracture of the humerus in a child aged six years with absence of the radial pulse and pallor of the hand

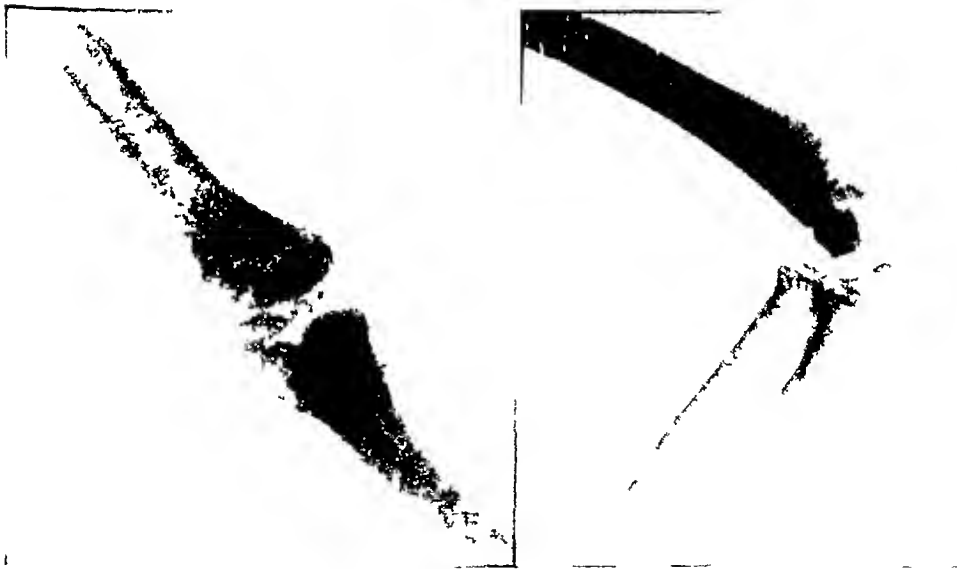


FIG 9

Manipulative reduction of the fracture in Fig 8 succeeded in restoring the circulation in the hand but the radial pulse did not return. Presumably improvement resulted from relief of pressure on collateral vessels

### SYMPATHECTOMY

If arterectomy is deemed necessary, or if operation results in anything short of full restoration of the circulation, the sympathetic supply of the limb should be interrupted. In the lower limb, if the condition of the patient permits, this is best done by lumbar ganglionectomy. With good modern anaesthesia this operation is neither difficult, lengthy, nor dangerous, and it should be part of the orthopaedic surgeon's standard repertoire. In the upper limb, however, adequate pre-ganglionic section is a different matter, and should not be attempted by occasional workers in that field.

However inexperienced a surgeon may be in operative sympathectomy, he is capable of paravertebral injection of procain. Such injections, repeated as necessary, will usually suffice and may indeed be all that is permitted by the condition of the patient. Simple methods of blocking the sympathetic supply to both upper and lower limbs are described in a Medical Research Council Memorandum on Arterial Injuries (1944), and by Gage and Ochsner (1940), White and Smithwick (1942), Caldwell, Broderick, and Rose (1946), etc.

As to the value of sympathetic block, operative or chemical, there can no longer be dispute. The experience of many surgeons in vascular centres in the recent war (Boyd 1946, Mason and Giddings 1945) has reinforced the experimental deductions of Barnes and Trueta (1942) and has not supported the fears of Cohen (1944) and Siddons (1945) that sympathetic block may even be harmful.

### DRUGS

Vaso-dilator drugs have been disappointing. Eupaverine (Denk 1934) is probably useful, papaverine is certainly not. Tetra-ethyl ammonium bromide (*vide* Berry *et al* 1946) is still on trial. It promises well as a means of paralysing the sympathetic, but it has potential dangers.

Heparin and other anti-coagulants may be indicated to prevent or limit thrombosis. Alkalies are of great value, and should always be given as a protection against renal failure. The only other useful drugs are morphine and other sedatives, which should be used freely.

### POST-OPERATIVE CARE

The first few post-operative hours are critical. All necessary measures must be taken to maintain an adequate systemic blood-pressure, for a good head of pressure will obviously help to force blood into an injured limb. Alkalies should be continued and since ischaemia of tissues obviously predisposes to infection, penicillin should be given as a routine. The limb should be slung on some "open" form of splintage, controlled but not compressed. It should be elevated just above the level of the heart unless the patient finds greater comfort just below that level. It should be kept cold, though not iced, in the shade before an open window. An electric fan is needed in hot weather. The rest of the body should be heated, even until the temperature rises to 100 or 101 degrees Fahrenheit. An electric blanket is useful.

Drugs play little part in the post-operative care. Sound sleep and freedom from pain should be obtained by the liberal use of morphia and of sedatives. Nicotine is a vaso-constrictor and there seems reasonable evidence for the prohibition of smoking. It is, however, consoling to note that alcohol is a vaso-dilator.

## SUMMARY

Ischaemia threatening an injured limb gives rise to the syndrome of pain, pallor, paralysis, and pulselessness. It is due to arterial injury by laceration, compression, intra-mural rupture or contusion, or to arterial spasm with or without demonstrable local arterial damage. The differentiation of spasm without local injury from organic obstruction is not possible by clinical methods.

*The suggested plan of treatment and of management is*

- 1 General systemic investigation (blood-pressure, blood-count, coagulation time, etc.)
- 2 Removal of all external pressure
- 3 Resuscitation
- 4 Direct attempt to relieve the obstruction by operation
- 5 Post-operative care

*The operative procedure recommended is*

- 1 Manipulative reduction of the fracture if possible
- 2 Proximal control of the artery
- 3 Arteriography
- 4 Exposure of the occluded artery (unless contra-indicated by time factors and by the anatomy of the collateral circulation), liberation and mobilisation of the vessel, repair by suture where such is necessary and possible, and arterectomy only for irreparable local damage
- 5 The provision of sympathetic block by injection or by sympathectomy

*The important elements of post-operative care are*

- 1 To maintain the blood-pressure while cooling the limb and heating the patient

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# THE CLINICAL DIAGNOSIS OF FAT EMBOLISM

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Three conditions which were responsible for high mortality in the recent war and for which there is not yet a fully agreed pathological explanation, or a specific form of treatment, are the crush syndrome, traumatic uraemia, and fat embolism. It is generally believed that fat embolism occurs more often in war wounds than in civilian injuries, but it is hoped to show in this paper not only that the frequency of the condition is under-estimated, and that recognition is comparatively easy provided only that the clinician is on the look out for it, but that it occurs in civilian injuries much more often than is thought. Of patients under my care in military surgical units during 1945 there were seven with fat embolism and, although the majority of all traumatic cases seen at that time were battle casualties, five of these seven were due to road accidents. The details are recorded in Table I.

TABLE I  
ANALYSIS OF SEVEN CASES OF FAT EMBOLISM

Case No	Site of injury	Type of injury	Onset	Petechial rash	Mental change	Fundus	Surgical therapy	Result	Duration
1	Femur	Road accident	Under 24 hours	Chest neck conjunctiva	Deep coma—three attacks	?	—	Died	14 days
2	Both tibiae	Road accident	2nd day	Chest back abdomen conjunctiva	Deep coma	?	—	Died	3 days
3	Femur	Road accident	3rd day	Conjunctiva few on neck	Slight wandering	?	—	Recovered	—
4	Femur	Road accident	Under 24 hours	Chest neck abdomen conjunctiva	Delirium—two attacks	Haemorrhage Oedema	Ligation of vein	Recovered	—
5	Femur	Shell wound	2nd day	neck conjunctiva	Deep coma	Haemorrhage Oedema	—	Died	5 days
6	Right femur left tibia	Road accident	2nd day	Conjunctiva few on neck later	Deep coma	Haemorrhage Oedema	Ligation of vein	Died	7 days
7	Tibia	Mine injury	2nd day	Chest neck conjunctiva	Deep coma	Haemorrhage	—	Died	9 days

During a three-month period after the cessation of hostilities, at two military hospitals in Germany, eighty-nine major injuries of the long bones were admitted. These included twenty-three fractures of the femur and forty-six fractures of the tibia, the majority of which were due to road accidents. Five cases of fat embolism were diagnosed, four were due to road accidents and the other to an accidental gun-shot wound of the lower end of the femur. Three proved fatal.

Wilson and Sahsbury (1944) reporting on 1000 consecutive battle casualties, including 119 fractures of one or more long bones, found that there was clinical evidence of fat embolism in eight cases of which six were fatal—a mortality rate of 75 per cent, or for all fractures

of long bones 5 per cent. Vance (1931), working in New York, reported that post-mortem examination of fifty-nine accident cases with fractures of long bones showed that 20 per cent had severe fat embolism and 55 per cent had moderate or slight fat embolism, that is to say that three-quarters of these civilian accidents with fractures of a long bone which proved fatal showed some degree of fat embolism. Robb Smith (1941), working in Oxford, reported that of 125 deaths due to accident, forty-one (33 per cent) showed gross fat emboli at post-mortem examination. In his paper he stated "There is little doubt that many of the complications of injury such as traumatic pneumonitis, delirium, delayed shock and blast are in reality fat embolism." To this list might be added concussion. The patient who is admitted with a fractured femur and a bruised or even fractured skull, and who lapses into delirium and coma, may easily be classified as a fatality due to head injury. Of ninety-three post-mortem examinations performed by Major in the Middle East in 1942 of which forty had a fracture of one or more long bones, seven deaths were due to fat embolism. These figures are given as examples of accumulating evidence that 1) fat embolism is a relatively common complication in fractures of the long bones, 2) the diagnosis is made less often before death than after, 3) it occurs almost as frequently in civilian accidents as in battle wounds.

Fat embolism usually occurs during the third and fourth decades and is more common in men than in women. It follows that in time of war, military services include a preponderance of those who are prone to this complication, whereas the civilian population is correspondingly depleted. Furthermore the gravity of wounds, and the long journeys down lines of communication over rough roads or tracks, may account for a higher incidence in war-time. But there is no evidence of any specific etiological factor relating to missile wounds. During peace-time severe accidents are less frequent and often they are treated by junior members of the hospital staff. The surgeon himself seldom sees the patient with a fractured femur who is admitted to a small remote hospital during the week-end rush on the roads and is dead within forty-eight hours. He is simply informed that an accident case with head injury died after admission from secondary shock, concussion, or cerebral haemorrhage. Fat embolism can so easily be mistaken, not only by the clinician but by the pathologist, that unless the possibility is kept constantly in mind the correct diagnosis will be missed. Many a petechia has blushed unseen by the surgeon who failed to pull back the bed clothes, examine the base of the neck, and inspect the conjunctival sac.

### PATHOLOGY

Fat emboli within the capillaries can best be found by the method described by Robb Smith in which a snippet of lung is cleared with potassium hydroxide. Microscopically there are petechial haemorrhages which may be distributed widely but are sometimes less obvious. Horizontal sections of the brain generally show a remarkable picture of densely packed petechiae throughout the white matter but none in the grey matter (Fig. 1).

Excellent surveys of the literature by Scuderi (1934) and Grossloss (1935) indicate the mass of experimental and pathological evidence which has accumulated, but there is still no proof as to the source of the fat. It may arise from the wound area, it may arise as an abnormality of general metabolic processes, or it may be that there is both embolism from the wound and general metabolic disturbance. Busch (1866) injected vermilion into the medulla of a long bone, fractured it, and after five minutes found pulmonary fat emboli stained with the dye. He showed that nearly all the fat travelled through the veins and not lymphatics. Gauss (1924) demonstrated that when veins inside the rigid walls of a bone are damaged they tend to remain open whereas those in soft tissue do not. At least one observer has found that blood taken from the femoral vein on the side of injury has a higher fat content than on the opposite side. Reiner (1907) reported good results from the application of a tourniquet, insertion above the tourniquet of a cannula into the femoral vein by way of the internal saphenous vein, release of the tourniquet, and drainage of the excess of fat.

On the other hand Lehman and Moore (1927) showed that the femur contained only a maximum of 65 c c of fat whereas the lethal dose, if man can be considered to show the same tolerance as the dog, is 120 c c. Groendahl (1911) found that ligation of the femoral vein and removal of the lymphatic inguinal glands on the side of injury did not prevent fat embolism. Vance reported post-mortem evidence of fat embolism not only in 75 per cent of fatal fractures of long bones but also in 12 to 14 per cent of non-traumatic deaths. Catsaras (1920) found fat embolism in the lungs of 18 per cent of sixty-seven patients dying from post-influenzal pneumonia. Fat embolism has been reported in a case of concussion without fracture (Ribbert 1894), in diabetes mellitus (Fitz 1881, Machlis 1924), in pulmonary tuberculosis (Heitzman), in chronic osteomyelitis (Field 1913), and after orthopaedic operations (Coolidge 1901, Codivilla 1910, Turner 1913, Schwamm 1926).



FIG 1

Horizontal section of brain showing many petechiae in the white matter but none in the grey matter (By courtesy of the British Journal of Surgery)

Whatever be the origin of the fat globules the view that their harmful action in the tissues is due to simple embolism and obstruction of blood-vessels cannot be accepted. Histological evidence shows that the fat, in disintegrating, causes destruction of the wall of the vessel with perivascular oedema and haemorrhage. A globule of inert fat would not be expected to act in this way. Hirsch (1941) pointed out that the reaction of tissues to unhydrolysed fat was similar to that of inert oil-like liquid petrolatum. On the other hand hydrolysis of fats liberates fatty acids and other chemical bodies which presumably are responsible for destruction of the wall of the vessel and for pathological changes in the perivascular tissues.

#### CLINICAL FEATURES

Scuderi (1934) concluded "The symptoms and signs are very difficult to elicit clinically. The symptoms are indicative only in a general way and are not at all conclusive. The signs are of more value but they are not conclusive enough." These observations were undoubtedly pessimistic. Only the lesser degrees of fat embolism, not endangering life, lack symptoms or signs to aid the clinician. In serious cases there are always signs, sometimes extensive

and obvious, but often unobtrusive and not recognised unless carefully sought. If the clinician knows what to look for, and where to look for it, the diagnosis is easy.

**Clinical history**—The typical clinical picture is that of a man in the third or fourth decade who in consequence of a road accident has sustained a compound fracture of the femur and is admitted to hospital, perhaps after a long and rough journey with the limb improperly immobilised, suffering a considerable degree of shock. The response to intravenous transfusion of blood or plasma is good, within three or four hours the blood-pressure and pulse rate are normal, and the patient is perfectly conscious and co-operative. Operative treatment of the wound and reduction of the fracture under intravenous and inhalational anaesthesia is arranged. An hour after operation the pulse is of good volume, the blood-pressure is maintained, and the general condition is satisfactory. The fact that consciousness has not yet been regained calls for no comment. Some hours later, however, when it is found that the patient is still deeply unconscious the possibility of fat embolism is brought to the fore. The patient may remain in this state and die quite soon, in which case the anaesthetist is liable to be blamed for a poorly administered anaesthetic, or the patient be blamed for an idiosyncrasy to the particular drug used. In such cases the anaesthetist should demand a post-mortem examination and a special search for evidence of fat embolism.

Other degrees of cerebral disturbance may occur. The patient is often unco-operative—refusing to eat food, refusing to use the urine flask, constantly calling for the nurse, repeatedly ringing his bell, and generally making himself a nuisance. This attitude, which is of important clinical significance, may well be overlooked in so far as it is not reported to the surgeon by the nurse. Other patients are restless or violent, perhaps needing two orderlies to keep them in bed. They may lie in a semi-conscious, delirious, stuporous, or comatose state with pale sweating skin and stertorous breathing. A patient may exhibit varying degrees of disturbance at different times, first sinking into deep coma, then regaining full consciousness, only to be plunged once more into coma when a fresh crop of emboli lodge in the brain. Alternate elevation and depression of consciousness due to successive showers of emboli is very typical and accounts for the association of fresh, recent, and old healing lesions of the brain which is often found at post-mortem examination.

**General clinical signs**—*Pulse*—The pulse rate is slightly raised, the volume is good. The veins are dilated and there is some dilatation of the right side of the heart. Killian (1931) reported dilatation of the heart in ten cases. *Blood-pressure*—The blood-pressure is normal or raised, thus at once ruling out the possibility of severe secondary shock. *Respiration*—There is respiratory embarrassment, raised respiration rate, frothing at the mouth, cyanosis, deep stertorous breathing, and often Cheyne-Stokes breathing in the terminal stages. There may be pain in the chest with signs of oedema and consolidation at the bases. *Temperature*—The temperature is high, a reading of 102–105 degrees is usual and it may go even higher in the terminal stages. *Central nervous system*—The signs are usually of a general nature with changes in the conscious state, muscle rigidity, loss of sphincter control, convulsions, and sometimes Jacksonian fits. Local signs such as facial paralysis (Aberle 1907), absent ankle jerks and positive Babinski response (Watson 1937) have been reported.

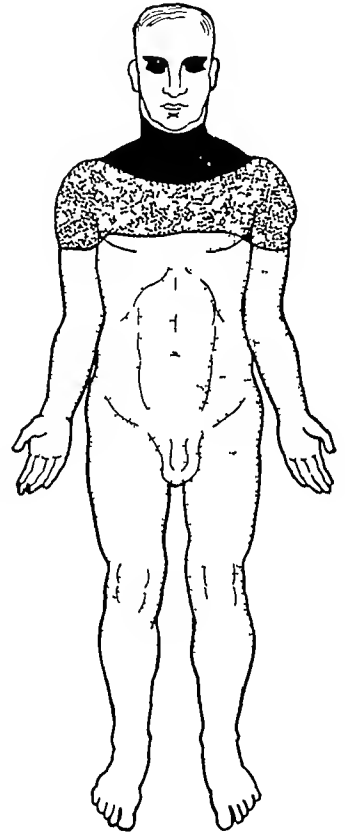


FIG 2

Petechial haemorrhages are most common in the supra-clavicular regions and the conjunctivae.



**Petechial haemorrhages**—Petechiae may be abundant or sparse, their number has no relation to the prognosis. When few, they are to be found at the base of the neck and in the conjunctival sac, they must be sought carefully in a good light or they may easily be missed. In the conjunctiva they occur chiefly in the inferior half, the lower lid must be pulled down to

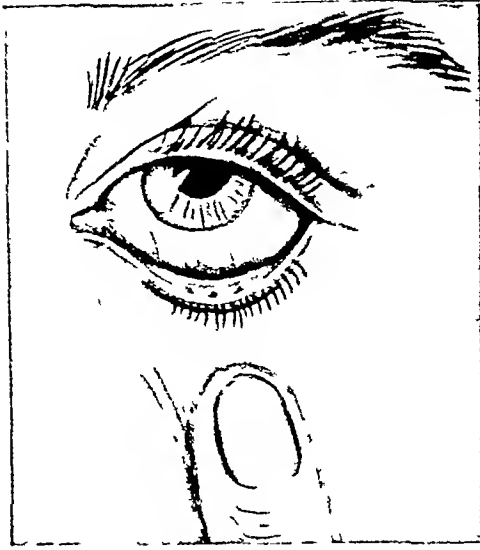


FIG 3

Three petechiae seen on the inner side of the lower lid

reveal them (Fig 3). Even in a case of grave prognosis there may be no more than one or two conjunctival petechiae. The other common site is the posterior triangle of the neck. When abundant they extend over the chest and abdomen and sometimes to the limbs. They are most thickly distributed over the neck, deltoid region, anterior aspect of the axilla and chest (Fig 2). They may appear in recurrent crops which synchronise with the attacks of coma.

**The fundus**—Globules of fat coursing through the retinal vessels were first seen by Muller (1860) and have been reported in a case of diabetes mellitus by Bantin (1926), these globules disappeared after the administration of insulin. Oppenheimer (1929) reported retinal fat globules in a case of fat embolism. This sign, however, is not the essential finding in fat embolism. More typical are the pathological changes in the substance of the retina itself, described recently by McArdle (1946). They consist of yellow-white glistening patches of perivascular oedema, or patches of perivascular haemorrhage, occurring along the line of the vessels (Fig 4). When searching for them each vessel should be traced from the disc to the periphery. It was not until the fourth case of this series came under my care that I learned of these changes from McArdle, but in the last four cases they were deliberately sought and were found in every one. Wilson and Salisbury (1944) were unable to find fat globules in the vessels but they make no mention of the retinal changes just described.

Examination of the fundus in a patient who is unco-operative or unconscious is not an easy task even for one who is skilled in this work. The patient may need quietening with paraldehyde, the room should be darkened, the pupils should be dilated with homatropine. The aid of an ophthalmologist is advisable.

**Fat in the sputum and urine**—Fat has been found in the sputum in patients suffering from fat embolism, but it has also been found in many other conditions and it is not to be regarded as a valuable clinical aid. Fat in the urine is more significant but is not easy to find and is frequently absent. Unfortunately it often does not appear until late in the course of the disease. It is important to remember that fat floats in the bladder on top of the urine and is therefore voided only with the last few drops.

**Blood examination and lung puncture**—It has been estimated that the smallest embolus which can obstruct a lung capillary has a measurement of 12 microns. It has been recommended that a specimen of blood be taken and a search made for fat globules in excess of this size. Lung puncture is another possible clinical aid and has been carried out in some case



FIG 4

The fundus showing petechial haemorrhages and oedematous patches

### Summary of Important Points in Diagnosis

- 1 History of injury, usually fracture of a long bone or severe soft tissue damage
- 2 Interval in which there are no symptoms or signs suggesting complications
- 3 Mental changes such as failure to co-operate, restlessness, delirium, stupor, or deep coma. Failure to recover consciousness from an anaesthetic
- 4 Alternate elevation and depression of the conscious state
- 5 Temperature 102 degrees or more. Blood-pressure normal or raised
- 6 Stertorous breathing, cyanosis, frothing at the mouth, moist sounds in the chest
- 7 Jacksonian fits and muscle rigidity
- 8 Petechial haemorrhages especially at the base of the neck and in the conjunctival sac
- 9 White patches of oedema or petechiae in the fundus
- 10 Blood urea usually normal. No anuria

Some of the conditions for which fat embolism may be mistaken are

- |   |                     |
|---|---------------------|
| 1 Secondary shock   | 4 Blast injury      |
| 2 Cerebral concussion   | 5 Crush syndrome    |
| 3 Cerebral compression  | 6 Traumatic uraemia |
| 7 Badly administered anaesthetic, idiosyncrasy to anaesthetic |                     |

### TREATMENT

There is no specific treatment and, when the condition has become established, very little can be done. Preventive treatment includes protection from long journeys over rough roads, and care to avoid unnecessary manipulation. Correct splintage is important. Siegmund (1918) showed that the longer the distance of transport to hospital, and the rougher the road, the greater was the incidence of fat embolism.

Deep incision into the wound with evacuation of the haematoma has been carried out by some surgeons on the assumption that local tension increases the liability of fat to enter the venous sinuses. Others, in simple fractures, aspirated the haematoma. Von Klapp (1931) ligated the femoral vein. Various substances have been injected intravenously. Wegelin (1923) injected sodium carbonate in an attempt to saponify the fat. Schanz (1910) injected physiological saline in order to flush out the cerebral capillaries. Yoshimasu and Killian put their faith in adrenalin. Since there is right-sided cardiac dilatation it is reasonable to suppose that intravenous infusion is detrimental. For this reason venesection has been advocated. Oxygen is valuable for cyanosed patients.

**Ligation of the profunda vein**—In view of the high mortality of fat embolism, and the lack of specific therapy, it has been thought justifiable to ligate the vein draining the injured area. Von Klapp advocated tying either the femoral or external iliac veins. Ligation of the femoral vein is a formidable procedure, not without risk to the limb, and ligation of the external iliac vein is of doubtful value in so far as it does not drain the femoral area.

Experience of ligation of the profunda artery, which proved a life-saving measure in cases of persistent secondary haemorrhage from compound fractures of the femur in wounded and debilitated prisoners of war, and which was never followed by vascular complications in the limb, stimulated me to consider ligation of the profunda vein as a means of arresting venous drainage from the area of the femur. It might be argued that such an operation is akin to shutting the stable door after the horse has bolted, but in this case it does seem that more than one horse is in the stable. The vein was ligated in two cases.

**Case 1**—Patient with severely comminuted fracture of the shaft of the left femur and small perforation of the skin from within. Twelve hours after the anaesthetic for reduction and immobilisation of the

fracture he became delirious. An extensive petechial rash appeared over the arms, neck and chest. Haemorrhages were present in both fundi and there was one patch of retinal oedema. He was taken to the theatre and the left profunda vein ligated through a vertical incision over the line of the femoral vessels from one to five inches below Poupart's ligament. The femoral artery was exposed and retracted medially to locate the profunda artery arising from its postero-lateral aspect. The profunda vein lies on the antero-medial surface of the artery (Fig 5). The patient was a little delirious after the anaesthetic and then recovered full consciousness. He did not relapse again and the rash slowly faded.

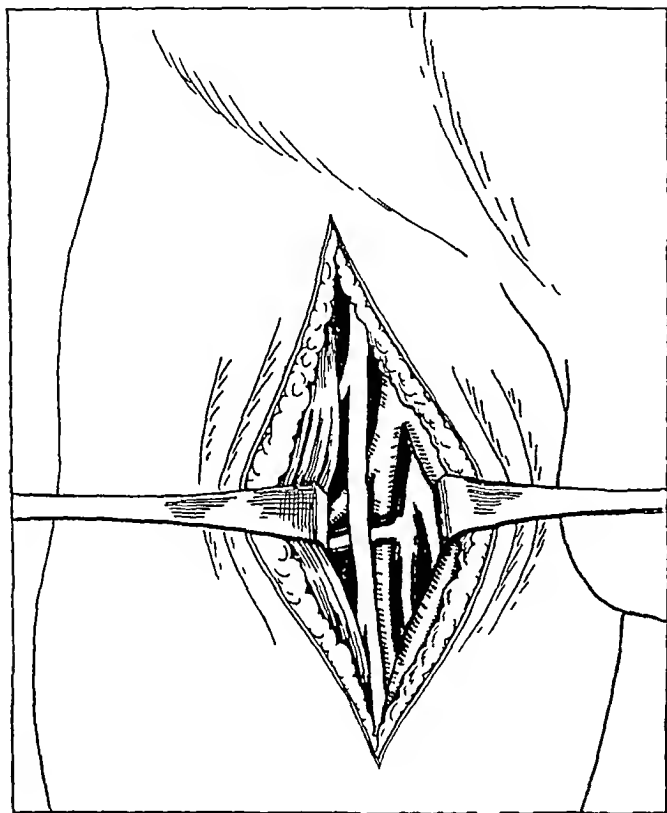


FIG 5

Operation for ligation of the profunda vein. The femoral artery is retracted medially distal to the origin of the profunda artery. This exposes the junction of the femoral and profunda veins.

**Case 2**—The patient had a fracture of the shaft of the right femur and a fracture of the shafts of the left tibia and fibula. He did not regain consciousness after the anaesthetic and remained in deep coma. There were a few petechiae at the base of the neck and in the conjunctiva. It was impossible to tell from which side the emboli arose but in view of the grave condition of the patient and the success of the previous operation, it was decided to ligate the profunda vein on the side of the fractured femur. The patient, however, remained in deep coma and died four days later.

No conclusions can be drawn from two cases but since the disease carries with it a high mortality, and the operation is simple, it may be considered worthy of further consideration and trial.

### SUMMARY

- 1 Fat embolism occurs in a high percentage of all cases of injury and it is a relatively frequent complication of fractures of the long bones in civilian accidents as well as battle casualties.
- 2 The diagnosis can usually be established by the clinical features together with certain physical signs which must however be sought deliberately.
- 3 Important clinical features are the mental disturbance, alternation of coma with full consciousness, petechial haemorrhages in the conjunctiva and skin, and typical changes in the retina.
- 4 Evidence is still conflicting as to whether the fat arises by embolism from an injured bone, or by general metabolic disturbance.
- 5 The fat is harmful not so much by reason of mechanical obstruction of vessels as by erosion and rupture of the vessel wall due to the liberation of fatty acids.
- 6 Preventive treatment appears to be of some value but no satisfactory specific treatment is yet available for the established case.
- 7 Ligation of the profunda vein has been tried in two patients, one of whom recovered and the other died.

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# PLASTIC SPLINTS AND APPLIANCES IN ORTHOPAEDIC SURGERY

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A wide range of plastic materials is now available in industry. It was thought that a number of these might be suitable for the construction of orthopaedic splints and they have been tried with varying degrees of success. Most have been found unsuitable for one reason or another, some because the technique of manipulation was too elaborate, and others because they were lacking in certain necessary qualities. The practical properties required of plastic materials for use in splint-making include relative ease of manipulation, durability, resistance to fatigue strain, light weight, radiolucency and transparency, inertness to chemical agents, freedom from irritants causing dermatitis, porosity, cheapness. No plastic material satisfies all these requirements but several are available which satisfy most of them. The ideal plastic will be one which after direct application to the patient, or to a mould, will polymerise rapidly to form a rigid material (cf. gypsum) or alternatively one which is soluble in high concentration, about 80 per cent, in a cheap solvent such as water. The curing or setting time must not exceed fifteen to twenty minutes and should preferably be less. Such a plastic when cured or set should have the properties enumerated above. We hope that this goal may be achieved by experimental work now proceeding.

Plastic materials may be divided into two main groups: 1) thermoplastic resins which can be resoftened and remoulded by the application of heat and pressure, 2) thermosetting resins which become more or less permanently hard and insoluble on curing (Worner 1946)<sup>1</sup>. The materials which have been considered experimentally for the construction of splints include *Thermoplastic*—methyl methacrylate, polyvinyl chloride (PVC), polyvinyl acetate (PVA), PVC & A copolymer, cellulose acetate, polythene, polystyrene, *Thermosetting—high pressure*—phenolformaldehyde, casein formaldehyde, urea formaldehyde, *Thermosetting—low pressure*—allyl and polyester resins.

It was hoped that new low-pressure thermosetting resins would eliminate some of the difficulties in processing which are found with high-pressure resins, and at the same time have the additional property of high tensile strength which non-laminated thermoplastic materials lack. To date, however, these materials have been found unsuitable for individual splint-making although experimental work in artificial limb production shows promise of success. Of thermoplastic materials, those nearest to our requirements have so far been methyl methacrylate, PVC and PVC & A copolymer—each having their usefulness in different types of splints.

It should be noted that if great strength is required a laminated plastic is essential. Laminating materials which can be used include glass fibre cloth, cotton, paper, and asbestos. Such lamination does, however, require modification of the usual technique.

External splints using woven cellulose acetate and glass fibre in bandage form have been described (Anderson and Erickson 1945)<sup>2</sup>. The plastic bandage is wetted with a setting solution and applied directly to the patient. A trial of these bandages shows that they have many advantages as compared with plaster-of-Paris bandages, but certain disadvantages have still to be overcome. Their merits include lightness of weight—not more than one-quarter to one-sixth the weight of plaster of Paris, strength and durability when in complete cast form, coolness in wearing, admission of light and air, capability of sterilisation by autoclaving, the fact that they are waterproof, porous, and unaffected by body secretions, and the ease and cleanliness of application. Nevertheless there are disadvantages: 1) The process involves evaporation of acetone which is an expensive and inflammable solvent.

<sup>1</sup> Australian Plastics 1, 26

<sup>2</sup> American Journal of Surgery, 69, 299

Great care must be taken that a dangerous concentration of acetone vapour does not accumulate. A case of acute acetone poisoning after the application of casts made of synthetic plaster substitutes in which the solvent-evaporating agent was acetone, and in which the route of absorption was by the lungs, has been reported by Chatterton and Elliott (1946)<sup>3</sup>

2) Slow setting—As in all evaporating processes a "skin" is formed on both surfaces of the setting splint through which the residual solvent trapped within, must diffuse before the splint can harden completely. 3) Sharp edges and rough surfaces are left when the cast has dried. 4) Hand-moulding to produce accurate fitting as in the technique of application of plaster of Paris is difficult. The use of crepe bandage which has been suggested does not give sufficiently accurate moulding.

Acrylic splints have been recommended by Campbell (1944)<sup>4</sup>, McGowan (1943, 1945)<sup>5,6</sup>, and Cholmeley (1945)<sup>7</sup>. The obvious advantages are elegance of appearance, low specific gravity, cleanliness in use and radiolucency. Blaine (1945, 1946)<sup>8,9</sup> holds that these merits are offset by too many drawbacks, but we do not share this opinion. We agree that indirect application by the dental technique is complicated, but there is no need to use such a method. We disagree that "the plastic splint allows sweat to accumulate, pruritis develops and the skin becomes smelly". Ventilation of the splint, as described later, presents no difficulty. Moreover plastic splints do not differ in this respect from plaster-of-Paris splints which are worn continuously for any length of time.

### SPECIAL TYPES OF SPLINTS

It might appear that hand manipulation of thermoplastics should be simple, for the reason that the materials become limp and "rubbery" when they are heated. Unfortunately this is far from true. The limp, heat-softened plastic alters shape readily in one or even two planes, but to mould it accurately against a plaster cast of a limb, and to hold it everywhere in apposition while cooling, requires considerable pressure and much skill. It is true that the construction of smaller splints presents relatively little difficulty but for large and complex splints, special technique and apparatus are essential.

Plaster-of-Paris casts are generally used in the manufacture of plastic splints because the temperature to which the plastic must be heated in order to allow successful manipulation is too high for direct moulding to the skin. Attempts to lower the softening point of thermoplastics, so that they can be hand-moulded to the body without burning the skin, can result only in a material which deforms under average living conditions such as sitting in front of a fire or in the sun. So far as practicable only *negative* plaster casts, easily taken by anyone conversant with plaster technique, were used in the production of these plastic splints. This technique is universally used and known. In the making of plastic splints care should be taken, especially where deep curves of small radius are present, to make the plaster cast several inches longer than the splint which is to be designed. Re-entrant curves at the edges of the cast must be avoided. Moreover it is desirable to grease the inside of the cast, or at least its edges and deep folds, with a lubricant such as petroleum jelly in order to allow the sheet plastic to flow easily while being moulded.

Of the two main groups of splints listed below, the smaller type can be made in any hospital with small workshop facilities. The larger type requires experienced technique and elaborate apparatus, but a supply would be practicable under a regional scheme of orthopaedic appliance manufacture without too great a cost of production.

*Group 1*—Small splints. 1) limb gutters, 2) angled splints (elbow, knee, ankle), 3) cock-up splints, 4) opponens splints, 5) insoles.

*Group 2*—Large splints. 1) anterior and posterior shells, 2) spinal jacket, 3) Minerva jacket and cervical support, 4) hip spica, 5) bucket and pylon, 6) plastic liner.

<sup>3</sup> Journal of the American Medical Association 130 1222

<sup>4</sup> British Medical Journal 1, 152

<sup>5</sup> Lancet 1, 805

<sup>6</sup> British Plastics 17, 30

<sup>7</sup> British Medical Journal 2, 585

<sup>8</sup> British Plastics 17, 331

<sup>9</sup> Lancet 2, 525

## GROUP 1—SMALL SPLINTS

For orthopaedic work, which generally entails the making of individual splints for individual patients, the use of standard shaped plastic splints is inadequate, even though it is claimed that minor local adjustments can be made by simple heating. Anyone who

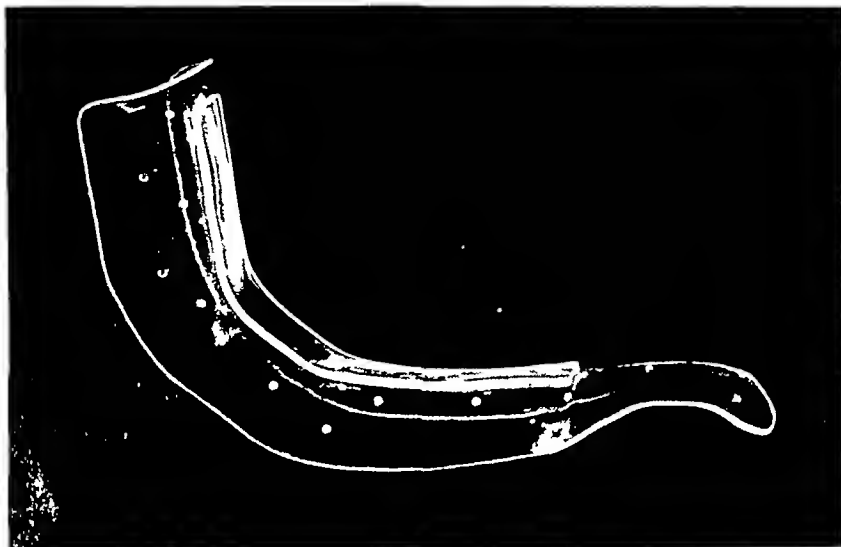


FIG 1

Angled anterior elbow splint with reinforcing bar



FIG 2

Knee gutter splint

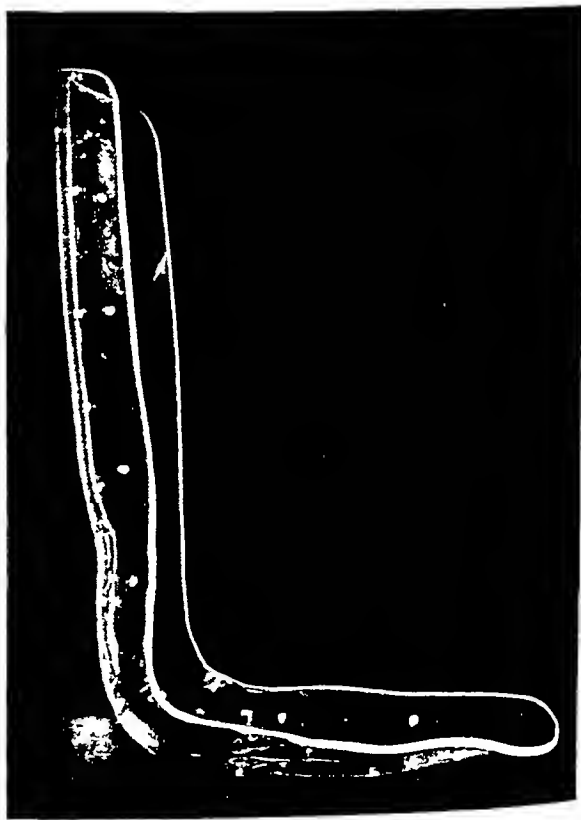


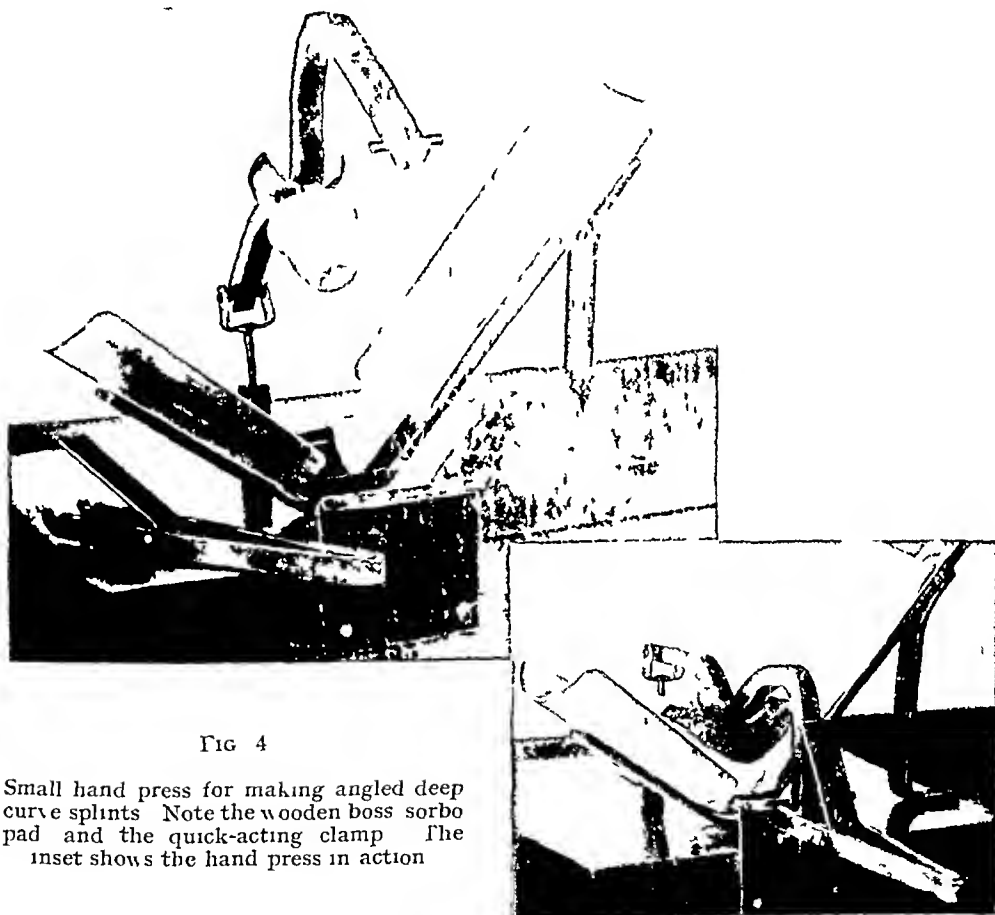
FIG 3

Ankle splint

can mould a standard splint accurately to fit an individual patient, can more cheaply make a much better splint tailored to the limb, starting with a negative plaster cast and a length of sheet plastic

**1 Upper and lower limb gutters** (one operator, Fig 2)—These splints are made by hand-pressing heated pieces of plastic sheet of appropriate size and thickness into negative plaster casts (Scales and Herschell 1945)<sup>10</sup> Such splints can also be made on positive plaster casts. As gutter splints obtained from direct moulding in a negative cast are adequate, it is unnecessary to increase cost and time of production by making positive plaster casts from the negative before processing. When enveloping splints are required, positive casts may be needed.

**2a Angled splints** (two operators, Fig 1)—Anterior elbow and posterior knee splints have been formed entirely by hand from sheet plastic of appropriate thickness (one-eighth or three thirty-seconds inch) cut to the approximate surface area required before



processing. It is important that the width of the strip should not exceed the segmental circumference of the cast at any level because excess material makes accurate hand-moulding extremely difficult. The strip of material is heat-softened and laid in the negative cast by the first operator, who holds it firmly in one half of the splint. The second operator then drags the remainder of the strip over the angle into the other half of the splint, holding it there and moulding it against the inside of the plaster cast until the material has hardened. Since there is considerable leverage on these splints it is advisable to cement a plastic strut across the angle.

**2b Angled splints** (one operator)—Posterior elbow and ankle splints (Fig 3) could not be made in this way because it was found impossible to secure sufficient pressure by hand to

<sup>10</sup> Scales J. T. and Herschell W. (1945) *British Medical Journal* 2, 423



reach the depth required for the heel or the point of the elbow where there are deep narrow curves in two planes. A simple hand press was devised by our technical assistant to overcome this difficulty (Fig. 4). It consists essentially of a right-angled metal rest to carry the plaster cast, bolted to a bench, and a quick-action clamp carrying a boss which is so fitted to the bench that, when it is brought over and locked, it presses a sorbo pad into the heel. The heat-softened tailored plastic strip is laid in the cast, the clamp brought over the heel portion and locked, thus forcing and maintaining the plastic to the full depth of the cast at the heel or olecranon. The foot and calf portion of the splint can then be moulded by hand. Using this simple apparatus the whole operation can be done in a few minutes by one technician.

**3 Cock-up splint** (one operator, Figs. 6, 7, and 8)—These are made by hand-pressing strips of plastic, which have been cut to approximate size, into a negative plaster cast. When cool, the moulded plastic is trimmed of excess material, and the edge of the palm area is everted to obtain a boss-like effect by careful local heating and finger manipulation.

**4 Opponens splint** (one operator, Fig. 9)—This splint, originally described by Cholmeley (1945)<sup>7</sup>, has been improved and is in common use at the Royal National Orthopaedic Hospital, Stanmore. So far, the best available materials have been found to be P.V.C. & A. copolymer, and methyl methacrylate, the former giving a better "spring" effect. It is made to fit the patient's hand, using only a paper templet. Fig. 10 shows a strip of copolymer, cut to pattern, and the finished splint. The templet can easily be varied in size to fit individual hands. *Technique* The tailored strip of plastic is carefully softened by heating over a diffused Bunsen flame, and the major curve is set freehand where it is judged that it will turn round the second metacarpal, will allow the tongue to lie in the first interosseous space, and will hold the thumb in the opposed position. The two secondary curves are then formed so as to turn round the estimated positions of the thenar and hypothenar eminences respectively, using careful local heating at the appropriate areas with a very small Bunsen jet flame. The tongue is next locally heated and turned over into the splint, and at the same time the edges of the tongue are fashioned to form two flanges. This flanged tongue will fit over the first web, holding the heads of the first and second metacarpals apart without causing harmful skin pressure. *Note* All heating of the splint is carried out away from the patient and the splint is applied only when cool. With practice, the number of fittings required during the making of it are few. This splint is the cheapest, easiest made, and most effective type yet evolved for opponens paralysis.

**5 Insoles** (one operator, Fig. 5)—Valgus insoles with or without metatarsal pads have been made experimentally by our technical assistant, using methyl methacrylate, "hard" P.V.C., and P.V.C. & A. copolymer. The method employed is to press a heat-softened piece of sheet plastic material of the necessary shape and thickness on to a wood last corresponding to the patient's foot size, using a simple hand-press apparatus. The insoles are then trimmed and drilled for ventilation. They have been found very comfortable in use but fatigue strain has occurred in the material, a fault which can probably be eliminated from sheet plastic in the future.

**Fixation of small splints**—Where a splint has to be held to a limb the methods of fixation include 1) overall crêpe bandaging, 2) adhesive strapping, 3) slot and strap (Fig. 7), slots are cut near the margin of the splint on both sides at appropriate levels and buckle straps threaded through, 4) stud and strap, shaped studs made from scrap material (Fig. 6a) are pressed into drill-holes in the long axis of the splint, the bases of the studs having been previously heat-softened, when cool these are held securely fixed, encircling soft straps are then fitted, one stud being sufficient for each strap, 5) combined slot, stud, and strap (Figs. 6 and 8). Straps may be either leather or plastic.

<sup>7</sup> Cholmeley, J. A. (1945) *British Medical Journal* 2, 585



FIG 5  
Insole made of hard PVC

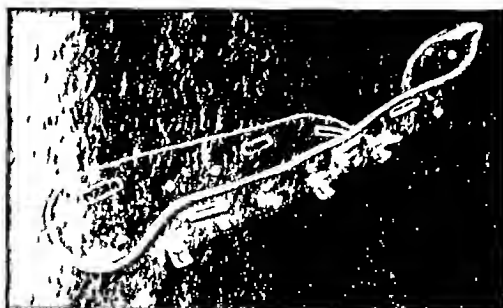


FIG 6  
Cock up splint with slots and studs

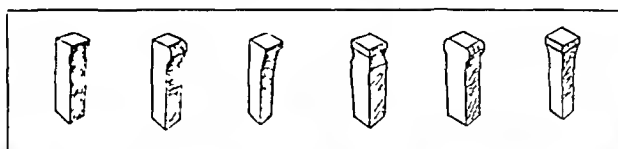


FIG 6a  
Hand made studs easily fashioned from scrap material

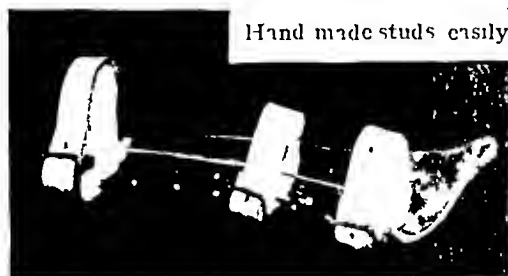


FIG 7  
Cock-up splint with slot and strap fixation



FIG 8  
Slot stud and strap fixation

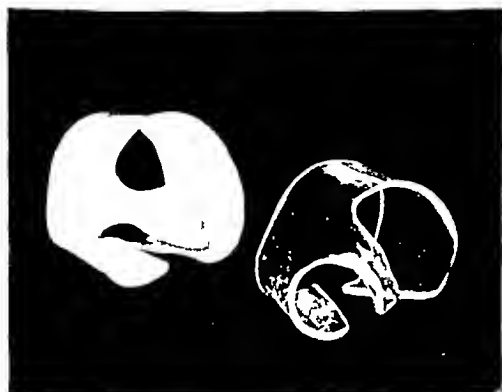


FIG 9



FIG 10

Opponens splints In Fig 9 the left splint is made of copolymer and the right of methacrylate Fig 10 shows a strip of copolymer cut to shape Note the set of the curves in the finished splint

**Ventilation of splints (small and large)**—As already noted, porosity is desirable Where such plastics as are being used lack this characteristic, ventilation is ensured by multiple small drill-holes of approximately one-eighth inch diameter

## GROUP 2—LARGE SPLINTS

This group requires two operators, a specially equipped workshop, technical skill, and experience of plastics. The splints have been made with thermoplastic material using negative plaster casts and pressure blowing. When made for special cases in which ordinary splinting was inadequate the results have been most gratifying. The stage has not yet been reached,

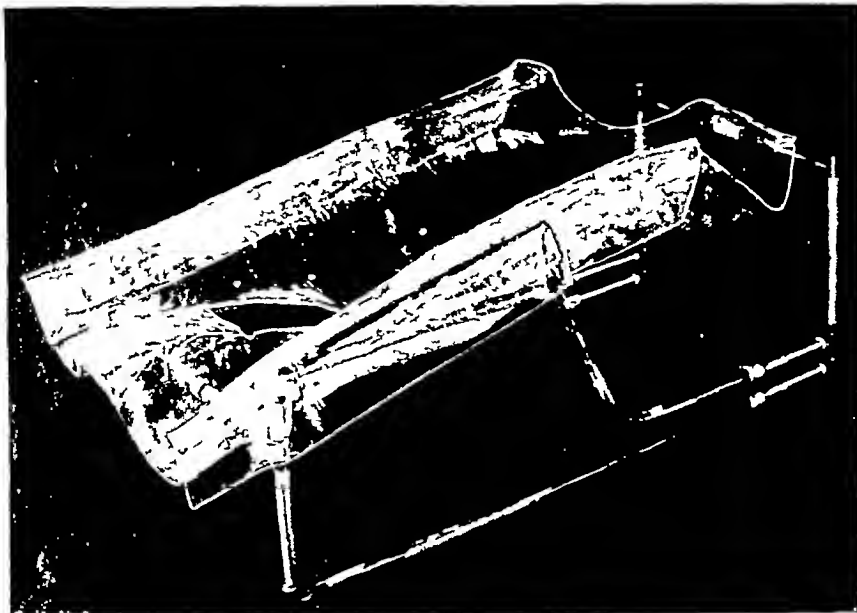


FIG 11

Posterior shell mounted on a standard adjustable frame

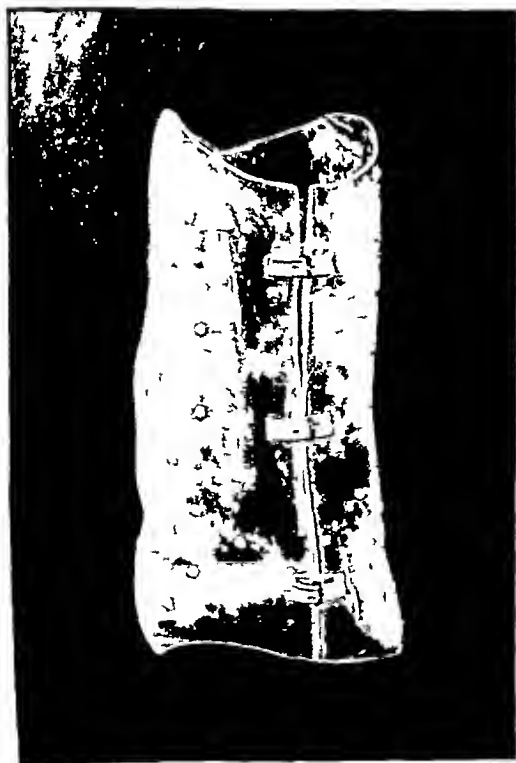


FIG 12  
Spinal jacket



FIG 13  
Minerva jacket

however where the routine use of such splints is practicable, owing to the present relatively high cost of plastic material. Experimental work with plastic laminates using negative or positive plaster casts are promising, and it may be that these can be developed sufficiently for routine use.

When plaster casts are used as negative moulds a modification is necessary to make them suitable for use in the pressure-blowing apparatus. This is a flange which is added by laying plaster slabs across the cast, allowing them to project two or three inches (Fig 18). In the case of anterior and posterior shells the flanges are formed automatically while the cast is being made.

**1 Anterior and posterior shells (Fig 11)**—The method of production of these large body shells has been described previously (Scales and Herschell 1945). It consists essentially in the use of a pressure-blowing apparatus in which a heat-softened sheet of plastic can be blown by compressed air into a negative plaster cast. The plastic mould is then cut out, drilled for ventilation, and mounted on a standard adjustable frame. If required, slots and soft straps can be used for strict immobilisation of the trunk and thighs.

**2 Spinal jacket (Fig 12)**—A plaster cast of the trunk is made in the usual manner, and bi-valved along the mid-axillary lines. The two halves are joined end-to-end and the whole is flanged with plaster slabs. When dry, this negative cast is placed in the pressure-blowing apparatus and a softened sheet of plastic material is blown to the shape of the negative mould. After cutting out, two plastic half-jackets are obtained which are finally trimmed, drilled, and fitted. The slot and strap method is used for fixation. The most suitable material for jackets so far used is methyl methacrylate, but it is probable that thermoplastic laminates will supersede it. Unlike celluloid jackets, as made at present with reinforcing duralumin strips, methyl methacrylate jackets need no reinforcement.

A laminate type of jacket has been described by Collinson (1946)<sup>11</sup>. There are, however, certain difficulties in its production which we also have found in experimental work with laminates. The main disadvantage of thermosetting resins such as used by Collinson (1945) is their tendency to cause dermatitis.

**3 Minerva jacket and cervical support**—These splints were used for special cases where immobilisation of the cervical spine was required. The Minerva jacket (Fig 13) has

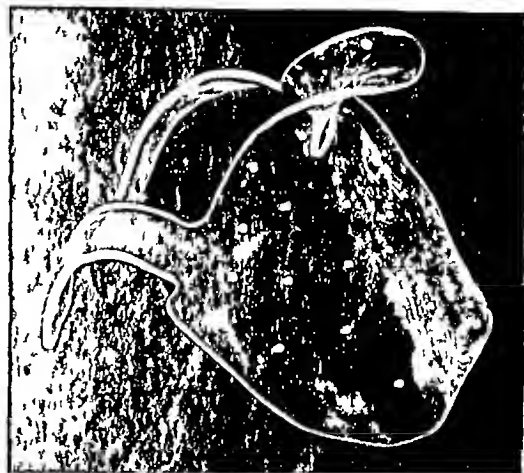


FIG 14

Cervical support with breast plate, chin support and shoulder straps—one piece moulding. No additional fixation is required.

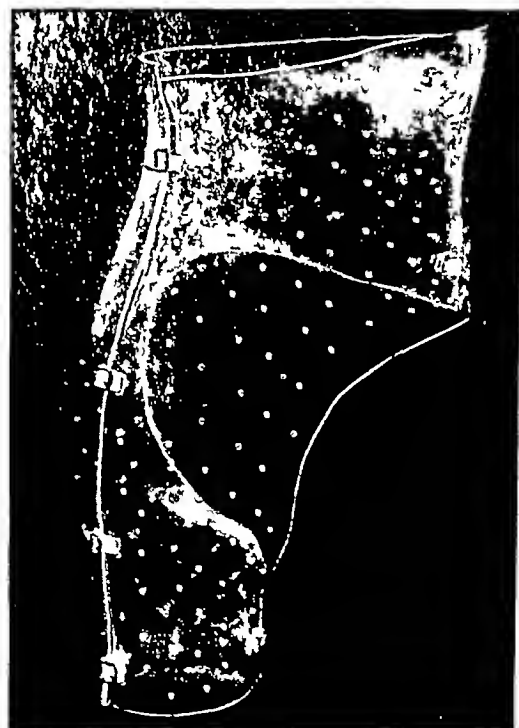


FIG 15

Hip spica

<sup>11</sup> Collinson H. A. (1946) *Lancet* 2, 215

been used *in toto* as shown, and also as two separate anterior and posterior splints in cases of laminectomy of the cervical spine. A negative plaster-of-Paris cast is taken, bi-valved, and flanged in the usual way. The two separate halves are used as negative moulds in the pressure-blowing apparatus to obtain corresponding plastic moulds which, after being cut out, form the completed splint. The two halves are held together by buckle-straps threaded through marginal slots. Owing to the depth of blowing necessary to form the forehead portion, the plastic is rather thinned out here and a flat reinforcing band is subsequently attached to strengthen it.

The cervical support (Fig. 14) is made from the anterior half of a negative plaster-of-Paris cast. After pressure blowing, the plastic replica is trimmed so as to leave a breast plate, chin support, and two shoulder straps. An aperture is cut to allow free movement of the thyroid cartilage during deglutition. To permit comfortable rotation of the head, the edges of the chin support are everted or bevelled. This cervical support remains in position without any additional fixation straps and is designed only to prevent flexion of the cervical spine.

**4 Hip spica** (Fig. 15)—This splint is also made from a bi-valved and flanged negative plaster-of-Paris cast, using the pressure-blowing apparatus. The two halves of the completed plastic splint are held together by buckle-straps threaded through marginal slots.

**5 Bucket and pylon** (temporary walking prosthesis) (Fig. 16)—Because of the disadvantages of a temporary plaster-of-Paris bucket and pylon, the possibilities of producing a more efficient temporary limb at a reasonably low cost, and without undue delay, were investigated. The disadvantages of a temporary above-knee plaster-of-Paris prosthesis are a) the form of the plaster bucket is such that the weight of the patient is not often taken on



FIG 16



FIG 17

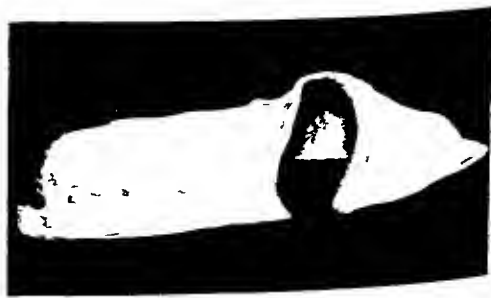


FIG 18

Bucket and pylon (Fig. 16). Note the simple slot and strap attachment and rubber heel. Fig. 17 shows a plaster cast of an above-knee stump with everted brim for ischial-bearing. Fig. 18 shows the two halves of the divided plaster cast being bridged and flanged; the negative has been left open on one side to show how the two halves are joined.



FIG 19

Simple apparatus for making plastic liner—the limb is held tightly clamped

that it allows full flexion of the thigh, and that it does not press into the perineum (Fig 17)

2) *Preparing the plaster-of-Paris mould*—When dry the negative cast is carefully divided longitudinally into equal halves (a surface gauge is a great help) These are placed on a flat

surface, cut margins downwards, and wide ends facing each other about two to three inches apart. Then by the addition of plaster-of-Paris slabs bridging the gap and projecting all round, a continuous negative mould with flanges is obtained. (See Fig 18—The cast has been left open one side to show the build-up.)

3) *Making the plastic mould*—When dry, the negative plaster-of-Paris cast is placed in the pressure-blowing apparatus. A three-sixteenth inch sheet of methyl methacrylate of appropriate size is heat-softened, clamped in the apparatus, and blown into the cast. When cool the plastic form is marked out in situ, then removed and carefully cut to yield the two halves. When cemented together with plastic dough these form an exact replica of the original negative plaster cast. The whole process can be completed in forty-eight to seventy-two hours, most of the time being needed for drying of the plaster-of-Paris cast and polymerisation of the plastic dough used

the ischial tuberosity as in a permanent artificial limb but around the circumference of the stump itself this causes a "step" or "roll" in the distal taper of the stump, and traction on the skin. b) for safe weight-bearing the plaster-of-Paris bucket has to be made thick, and when the pylon is attached the whole prosthesis is far too heavy, c) the stump sometimes becomes irritated by poor ventilation of the bucket.

#### Method of production of a plastic bucket—

1) *Making the cast*—The first step is to attach with adhesive tape a length of medium bore pressure rubber tubing obliquely round the upper part of the thigh at the level of the ischial tuberosity postero-medially, and the base of the greater trochanter laterally. This ensures a properly shaped everted brim and ischial-bearing point in the finished plastic bucket. A length of stockinette is then applied over the stump, and plaster-of-Paris bandages used to make the cast. When set the cast is removed, the stockinette drawn out and the cast reapplied to make sure that it is an accurate fit,

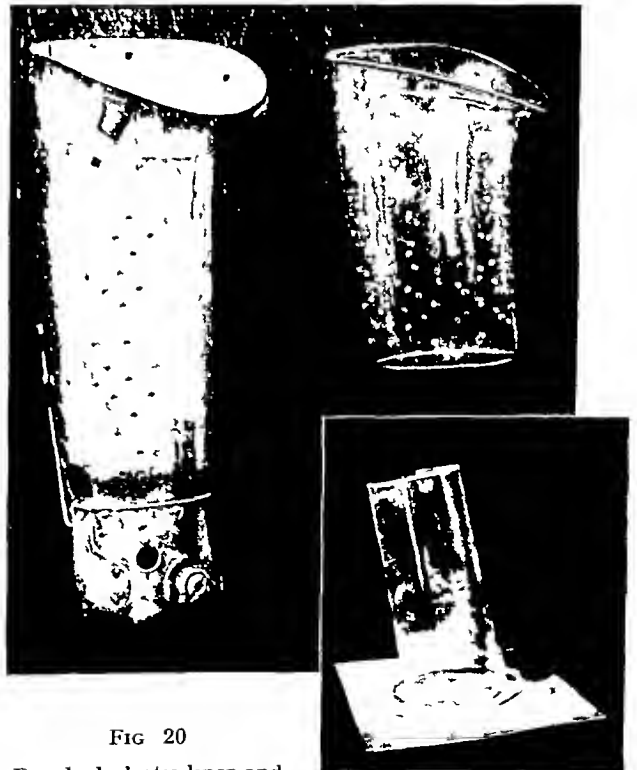


FIG 20

Finished plastic liner and metal bucket for which it was made. Inset shows the standard shape used for making plastic liners

in joining the two halves together Ventilation is ensured by drilling the material with one-eighth inch holes after the cementing operation *Fixation* The bucket is secured with plastic dough to a plastic pylon, preformed round a mandrel, and the suspension strap passed through slots cut in the cup of the pylon The prosthesis shown in Fig 16 has been worn successfully by a patient before the fitting of a permanent artificial limb It was made entirely of methyl methacrylate, its total weight being  $3\frac{1}{2}$  lb It is suggested that this method of bucket construction could be used in conjunction with a cheap, standard, jointed, and adjustable, artificial limb before the permanent limb is supplied to the patient This temporary apparatus could be used for more than one patient by the simple process of changing the bucket In this way the stiff-legged swinging gait which may develop with a straight-knee walking apparatus can be avoided

**6 Plastic liner**—When a permanent artificial limb is supplied to a patient it is an advantage to be able to take up the steady shrinkage of the stump which often occurs over prolonged periods For this purpose a plastic liner was evolved which is an exact fit in the above-knee metal bucket of the limb It is capable of withdrawal and replacement by another liner of different thickness if required and is individually produced to fit each metal limb without any damage to it *Method of production*—Standard "shapes" of methyl methacrylate have been constructed in four or five sizes (Fig 20 inset) In appearance they are rather like a Welsh hat with crown set at an angle to the brim A "shape" is heat-softened and placed inside the previously warmed bucket of the fully assembled limb With the knee flexed at 90 degrees the upper part of the limb is held in the apparatus shown in Fig 19 By clamping the flange of the "shape" between the two base-plates and releasing compressed air into it, the whole shape takes up the exact form of the inside of the bucket Pressure is maintained until the material has cooled The shape is removed and trimmed of excess material (Fig 20) It has been found advantageous to grease the inside of the metal bucket to allow the plastic material to slide easily in it, and so prevent damage to its cellulose finish Ventilation holes are easily drilled in the liner to correspond with those in the bucket The time taken to produce such liners is approximately two hours The apparatus required is not costly or elaborate The patient is able to continue wearing his artificial limb to which he has become accustomed

## CONCLUSIONS

The advantages of plastics are well known, but there are still some who maintain that these materials are costly and difficult to manipulate It is not usually remembered, however, that plastics already have their place in orthopaedic splint manufacture, for example in celluloid appliances of many kinds which are in everyday use They are much lighter than plaster of Paris, they are unaffected by water and body secretions, and some are radiolucent With the rapid development of modern plastics now taking place there is a wide field for research into their application in orthopaedic surgery In describing a range of plastic splints and appliances, and outlining the details of their construction, we have tried to show that such research is worth while

We wish to thank the Royal National Orthopaedic Hospital for facilities given us in carrying out this work and the Resident Surgeon Mr J A Cholmeley F R C S, for his interest and help

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# TRAUMATIC URAEMIA

## A COLLECTIVE REVIEW

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Traumatic uraemia has been considered largely in association with crushing injuries, but more recent evidence indicates that renal failure with characteristic biochemical changes and clinical features may be due also to trauma of non-specific type [53, 54, 100, 125], and to many other conditions of apparently different etiology [71, 111]. The pathological changes are now well established [37, 100].

### HISTORICAL REVIEW

Early references to traumatic uraemia were all associated with injury of a crushing type. Colmers [45], who was sent to the relief of victims of the Messina earthquake, noted that crushing of limbs by falling masonry was almost universally fatal. The condition was largely overlooked during the First World War, despite the crushing injuries of trench warfare [32, 72, 84, 94]. Minami [119] suggested that renal failure was due to the toxicity of myohaemoglobin released from damaged muscles. He based his conclusions on three factors: 1) that the crushed muscles were pale and oedematous, thus suggesting loss of pigment, 2) that there were haemoglobin casts in the damaged kidney tubules, 3) that there was similarity between this form of uraemia and equine paralytic myohaemoglobinuria, a comparison which was confirmed by Gilmour [75]. Bywaters [33] and others described the classical sequence of events which they termed "crush anuria" [14]. This syndrome became well known during the years 1941-43 and most observers accepted the view that release of myohaemoglobin from damaged muscles was the principal cause of the renal failure [21, 36, 39, 68, 101, 112, 115, 117], this view being strengthened by identification of the pigment in the kidney tubules and in the urine [34, 35]. The histological findings were, however, indistinguishable from those of incompatible blood transfusion (the use of stored blood being at that time in its infancy). Nevertheless a case reported by Mayon White and Solandt [116] proved that blood transfusion was not necessarily an etiological factor. Moreover doubt was expressed as to whether muscle damage was the essential cause, and when Glen [76] recorded a fatal case of uraemia after damage to the iliac artery, but without crushing injury, the problem assumed new complexity. Shortly afterwards other writers reported cases with the same histological pattern due to different etiological factors [31, 155, 156], and Foy [71] made the first real attempt to correlate the many conditions which might be responsible.

In 1944 clinicians who studied cases of blackwater fever [109] and gun-shot wounds [53, 125] found difficulty in accepting the view that haemoglobin and its derivatives were nephrotoxic and suggested the theory, supported by experimental evidence [46, 48, 98, 118], that the mechanism of renal failure might be lack of blood supply due to shock, hypotension, or renal vaso-constriction. Maegraith, Havard, and Parsons [111] suggested that the essential etiological factor was "renal anoxia". Nevertheless traumatic uraemia seemed to be associated particularly with crushing injury, and Lucke [100], after examining 538 fatal cases and excluding those due to sulphanilamide poisoning or incompatible blood transfusion, came to the conclusion that in 57 per cent of cases severe trauma was the important cause.

Despite this clear association of uraemia with injury there has been increasing evidence of similar biochemical and histological changes in the kidneys from many different causes,



TABLE I

Group 1 Shock	Group 2 Electrolyte water balance	Group 3 Pigment	Group 4 Allergy	Group 5 Chemical nephrotoxin
Gun shot wounds [53 54 67, 125]	Haematemesis [18 15]	Crush anuria [122 14 21 33 36 37 41 66 88 99 119]	Favism [71]	Mushroom poisoning [100]
Shock [121]	Pyloric stenosis [108] with vomiting [105]	Incompatible blood trans- fusion [6 151]	Sulphanilamide (some forms) [16 22 134 132 154]	Oxalate [63]
Head injury [51, 52]	Acidosis [85 90, 101]	Burns [9 114]	Serum sickness [131]	Mercuric chloride [128]
Severe injury [93, 81]	Alkalosis [104 107 123]	Yellow fever [111]	Incompatible blood trans- fusion (some form) [89 115]	Alloxan
Post operational azotaemia [15]	Cholera [44, 142]	Hepato-renal syndrome [30 111]	Pitressin [146]	Phosphorus [128]
Post-partum haemorrhage [155]	Addison disease [43]	Blackwater fever [71, 109 111 138 149]	Epinephrine hydrochloride [146]	The bite of the lactro dictus mactaus (Black Widow) [128]
Concealed accidental hae- morrhage [156]	Hypochloroemia [20 24, 25, 113 26, 27, 102, 103 104]	Guinea paralytic Myohaemoglobinurea [75]	Staphylococcal toxin [146]	Cresol poisoning [128]
Septic abortion [31]	Dehydration [133, 71]	Weil's disease [111]	Meningococcal toxin [23]	Carbon tetrachloride [152]
Reflex anuria [50]	Diabetic coma [101 15]	Heat stroke [100]	Typhus fever [3]	Phosphate [61, 107]
Hysterical anuria [146]	Intestinal obstruction [15]	Icterus neonatorum [120]		Uranium [92]
Vascular injury [76]	Repeated haemorrhage [118]			Uric acid [64]
Anoxia [19]	Pernicious anaemia [139, 140]			
CO poisoning [60]	Decreased fluid intake [15 29]			
	Pneumonia [15]			
	Potassium excess [70]			
	Sodium lack [73 96]			

and observers have been struck by the similarity between these conditions and both traumatic uraemia and crush anuria. The list of possible etiological factors has now become so vast that they cannot be given in full. They are, however, summarised in five groups in Table I. Despite some overlap, each group is distinguished by an outstanding etiological feature—for example in group 1 the common factor is shock, in group 2 disturbance of the electrolyte water balance, in group 3 presence of pigment in the circulation, in group 4 an allergic basis, and in group 5 factors of chemical nephrotoxins.

**Shock and renal function**—Ever since the original work in 1937 of Husfeldt and Bjerling [93] on renal failure due to injury it has been clear that shock, whether or not accompanied by blood loss, is characterised by failure of renal secretion. Van Slyke and his team [59, 129, 147] showed that when shock was due to bleeding or injury there was progressive decrease in the flow of blood through the kidneys, and that when fluid loss amounted to 40 to 50 millilitres of blood per kilogramme renal blood flow and secretion of water fell almost to zero level. These authors drew analogy between the renal function of dog and man, and stated that in human beings with anuria due to severe and prolonged shock it was possible to restore the kidney circulation by blood transfusion without gaining sufficient renal function to prevent death from uraemia some days later. Other observers noted that after blood transfusion, oxygen extraction of the kidney was not increased proportionately to the increase in other parts of the body, which was even more remarkable in view of the fact that the decreased blood in the kidneys was due to constriction of the renal arterioles. This important observation suggested a possible shunt mechanism whereby certain areas of the renal bed were by-passed. Such a theory is supported by studies in the renal circulation, published in 1947, by Trueta *et al* [146]. It has been confirmed by other workers who showed that experimental tourniquet shock was accompanied by considerable alteration in the blood flow of the kidneys [95]. Unfortunately it has not been possible to reproduce the conditions of crush anuria in animals [38, 62, 69] because they are unable to withstand the shock of the procedure, and moreover myohaemoglobin in these animals is not in labile form [147].

No less important in determining the essential factor of traumatic uraemia was the work of Cournand [48] and Lauson *et al* [98] who carried out precise clearance tests in conditions of shock. They demonstrated that there was reduced blood flow to the kidney which might be due in part to renal vaso-constriction but might also be due to changes in renal haemodynamics. This work answered effectively the theory that reduced renal blood flow in shock was due to hypotension (Maitland [112], Tombs [143], and Moon [121], who went so far as to say that the syndrome was a direct sequel of shock). Recently it has been shown that there is neurogenic control of the renal circulation. Trueta [145] observed that over-stimulation of the peripheral nerves in shock might cause persistent spasm of the renal and other arteries. Trueta and Barnes proved that trauma applied to one limb cause widespread arterial spasm extending to vessels of the other limb and to those of the viscera [11]. Trueta and others also showed that renal ischaemia could be produced by stimulation of the splanchnic nerves, and that similar changes could be produced by shock, bleeding, and crush injury. They drew attention to the fact that anuria could be induced reflexly and by emotional disturbance [146].

**Electrolyte water balance and kidney function**—Disturbance of the electrolyte water balance has been the subject of much research, and it is now established that water deficiency [71, 133], hypochloraemia [20, 103, 113], alkalosis [104, 108, 123], acidosis [85, 90, 101, 96, 73], and loss of available base, are accompanied by rise in blood urea and non-protein nitrogen [15, 29, 113]. These conditions have been ascribed to extra-renal azotaemia for the reason that post-mortem studies have shown no gross histological changes in the kidneys. But evidence in human cases and animal experiments has suggested that there is not only oliguria but also fall in the glomerular filtration rate. Similar changes are found in dehydration due to insufficient fluid intake, intestinal obstruction [15, 29], diarrhoea [44], and

gastro-intestinal haemorrhage [13, 19] Recent opinions suggest that hypochloraemia is of greater importance than was formerly believed [113] but it is not always possible to determine clinically which of these factors is most essential for the maintenance of renal function because there is a constant effort in the body to maintain and adjust the electrolyte water balance [4] Kidney function is often restored by correction of the missing factors, but it must be recognised that when renal failure has already supervened, maintenance of the electrolyte water balance requires much judgment and care [5, 54, 110]

Although azotaemia has been thought to result from excessive breakdown of protein it is now suggested that histological changes in the kidney are worthy of more study [15] There may be degeneration of renal tubules and even cast formation [108] More recently Verney's work [148] has shown that liberation of an anti-diuretic hormone from the posterior pituitary is dependent upon osmotic pressure in the arterial plasma It is known that in cases of water depletion, intestinal obstruction, and cholera, there is considerable alteration in the plasma osmotic pressure which may lead to renal failure and azotaemia [113]

**Haemoglobin and kidney function**—Hitherto most observations have been made in attempting to determine the cause of renal failure in blackwater fever and incompatible blood transfusion Much of this work is hypothetical, many authors being insufficiently aware of the difficulties of producing a sterile, stroma-free haemoglobin, and often failing to state the amount of haemoglobin used in various experiments The experiments of Barratt and Yorke [12], Yorke and Naus [153], and Baker and Dodds [10] are misleading They produced haemoglobinuria in rabbits and found that anuria developed when the animals were acidotic They concluded that precipitation of haemoglobin in acid urine caused death by obstruction of the tubules and that the remedy was to maintain an alkaline urine Later investigators, while confirming the significance of acidity of the urine, gave conflicting evidence as to the particular haemoglobin derivative which was responsible [17, 40, 55, 56] This work has been criticised on the grounds that acidotic rabbits are dehydrated and for this reason are liable to develop uraemia in any case [71] Gersh [74] injected the haemoglobin of pigs into rabbits and found that cast formation was greater if the animal was dehydrated Govan and Parkes [80] found that acidosis in the rabbit caused degeneration of the renal epithelium Convincing proof was also put forward by many workers [8, 13, 28, 57] that haemoglobin and its derivatives were not toxic provided only that they were sterile and stroma-free This was confirmed by clinical reports, for it was found that haemoglobin is excreted freely in blackwater fever [138], and that uraemia may develop equally in the presence of acidosis, alkalosis, or a normal alkali reserve [109, 149] These findings are supported by our own observations which showed that severely wounded men often excreted myohaemoglobin without developing uraemia

Light has been shed on the subject by Yuile *et al* [158] who showed that when the kidney was damaged by sub-lethal doses of sodium tartate, or by incomplete occlusion of the renal artery, the addition of stroma-free haemoglobin caused fatal uraemia of the type seen in blackwater fever and in traumatic uraemia Nevertheless the explanation of the initial injury to the kidney is still wanting Ingenious theories have been postulated Bavalis [13] suggested that although stroma-free haematin of the blood is non-toxic, globin produces an anaphylactoid reaction which is most marked in the kidney Later workers suggested that a similar mechanism may be responsible for renal vaso-spasm [89, 115, 127, 150]

**Allergy and kidney function**—Although it appears that excretion of haemoglobin is not itself the cause of renal failure, it is nevertheless true that fatal uraemia is a common sequel to many forms of incompatible blood transfusion It is possible that, as a result of haemolysis of blood, an antigen is liberated which not only causes general circulatory failure but has specific vaso-constrictor action upon the renal arterioles, which is then followed by irreversible renal damage [6, 89, 115, 127] Similarly it has been suggested that sulphanilamide anuria may be due to hypersensitivity of the kidney to combined protein

sulphanilamide, a combination which may occur is the result of intolerance to this group of drugs [16]. In support of this theory Low *et al* [71] believed that the perplexing form of anuria which may follow the eating of broad beans, and is known as "favism," could be explained by protein sensitivity. More recently Black-Schaffer *et al* [23], studying the Schwartzman phenomenon, produced experimental cortical necrosis of the kidneys in rabbits, presumably the result of an antigen-antibody response to injections of specially prepared cultures of meningococci. Similar results have been secured with staphylococcus toxin [146]. This mechanism may account for the renal changes which are produced by pitressin and epinephrin hydrochloride. The hypothesis is also supported by the finding of azotaemia in serum sickness by Rackemann *et al* [131].

**Chemical nephrotoxin and kidney function**—It is well known that certain chemicals have specific nephrotoxic action and that necrosis of the tubular epithelium is caused by such substances as mercuric-chloride, oxalates, phosphates, etc. These substances appear to be precipitated in the loops of Henle as the result of a fall of the pH of the glomerular filtrate [66]\*. Such toxic materials may cause necrosis of renal epithelium by direct action, but equally they may give rise to vaso-constriction of the renal arterioles as a reflex defence mechanism, thus explaining reflex anuria [50] and the anuria of incompatible blood transfusion [89, 115, 127].

Such histological findings suggest that in each of the five groups there is sufficient alteration of blood supply to cause necrosis of renal epithelium, but before discussing this statement it is well to examine the evidence from post-mortem and histological findings.

#### AUTOPSY FINDINGS

Macroscopic findings are few. When death occurs in consequence of crushing injury, incision of the injured muscles shows oedema, swelling, and pallor, with obvious loss of pigment. It is important to note that the skin overlying the injured region may show little or no change. Not infrequently there is also fat embolism with a characteristic petechial rash and changes in the brain, lung, and other organs. There is often oedema of the lung with cardiac dilatation. This appears to result mainly from difficulty in controlling intravenous therapy rather than from the uraemia itself, but it may be due to peripheral vascular failure. Probably the only characteristic change of the syndrome of traumatic uraemia is in the kidney itself which is increased in weight. The capsule is under tension. On section, the cut surface is everted and the cortex is pale, it has a yellow, granular sheen. The pyramids and medulla stand out in contrast and are brick red in colour. When uraemia is due to sulphanilamide therapy, crystals may be seen pouting from the pyramids or in the terminal parts of the tubules.

**Histological findings**—In tracing the nephron through its course it is found that the glomeruli usually show little or no change, although there is noticeable lack of blood in the tufts themselves. In some areas the glomerular spaces are filled with an albuminous deposit which is most marked round the periphery and is adherent to Bowman's capsule. The epithelium of the first convoluted tubule shows early degenerative change and the cytoplasm stains irregularly, the nuclei are pyknotic and there is usually an eosinophilic catarrh of the lumen. These changes are observed both in traumatic uraemia and in death from intestinal obstruction [15]. The most marked damage occurs, however, in the loops of Henle, for which reason it has been named by Lucke "lower nephron nephrosis" [100]. Degeneration of epithelium in this area is frequently patchy and the tubule is sometimes so distorted as to make it impossible to tell whether it is of the ascending or descending type. The importance of this widespread degeneration is often overlooked because there is a wide

\* Since writing this article Harrison *et al* have shown that this can no longer be accepted since they have found that the casts removed by micro dissection are freely soluble in pH of 6.6 or lower and insoluble in an alkaline medium. (Journal of Experimental Medicine 1947 86, 339.)

variety of casts, mainly of two types, some composed of protein and others of pigment origin. The structure of the casts is of interest, they tend to form round particulate matter such as degenerated epithelial cells or crystals such as sulphanilamide. In many cases the epithelium is stripped and adherent to the outer surfaces of the cast. Another curious cast, which stains red with Mallory and may contain pigment, is granular in appearance and consists of many distinct minute fragments. The ascending convoluted tubule also shows complete destruction with desquamation of epithelium which is stripped in a plicated concertina manner [37]. All types of cast formations are seen. Occasionally the cast is arranged peripherally in the form of a hollow cylinder [42]. The collecting tubules show degenerative changes, often with casts showing evidence of regeneration and polymorphic infiltration. When sulphanilamide has been a factor, the lumen of the collecting tubules may be encrusted with crystals. The intermedullary and interstitial tissue is congested.

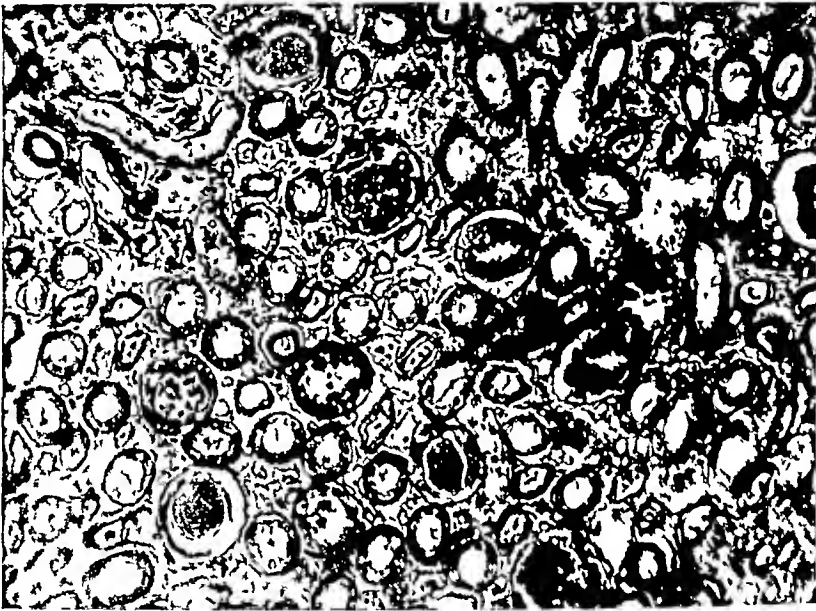


FIG 1

Section at the level of the loops of Henle showing the wide variety of casts which tends to obscure the tubular degeneration

One of the most interesting features is the occurrence of venous thrombi in the boundary zone associated with rupture of tubules into the veins [37, 66]. When serial sections have been cut it has sometimes been found that thrombi are adherent to a local lesion of the vein without evidence of tubular rupture [54]. The interstitial tissue at this point is infiltrated with lymphocytes and histiocytes. In other cases this infiltration may be isolated, and when an allergic origin is postulated they may be largely eosinophilic. Other investigators of the renal arterial system have shown the presence of abnormal cells in the juxta-glomerular complex. Goormaghtich [77, 78, 79] showed that such cells are more plentiful in peripheral cortical areas in the crush syndrome and may also be produced by incomplete ischaemia of the rabbit's kidney. The cells are thought to excrete renin and are said to be responsible for the hypertension which is a clinical feature.

The only other histological finding which may be of significance is necrosis of the central vein of the liver. In patients who survive for several days this is accompanied by reticular replacement and early fibrosis.

#### DISCUSSION

Of etiological theories which have been advanced, that of tubular blockage has now been generally discarded. Nevertheless Bywaters [41, 42] renewed interest in this theory.

and suggested that oliguria might be due to failure of reabsorption from the second convoluted tubules by reason of the deposition of pigment in the form of a hollow cast. Such a deposit would cause destruction of epithelium and renal failure. A closely allied theory was suggested by Peters [128] who claimed that renal failure was due to rise in the intra-renal pressure. He believed that the primary cause of oliguria or anuria was decrease in the effective filtration pressure caused by interstitial oedema and dilatation of the tubules due to inflammatory changes produced by nephrotoxin. This theory gains support on histological grounds because there is marked interstitial oedema but the absence of dilatation of the tubules and of the glomerular spaces makes it unlikely.

In a previous communication the author suggested that tubular degeneration was the precursor of this syndrome [54]. It is a matter for debate whether this is caused by nephrotoxic agents or by disturbance of the renal circulation. Supporters of the nephro-

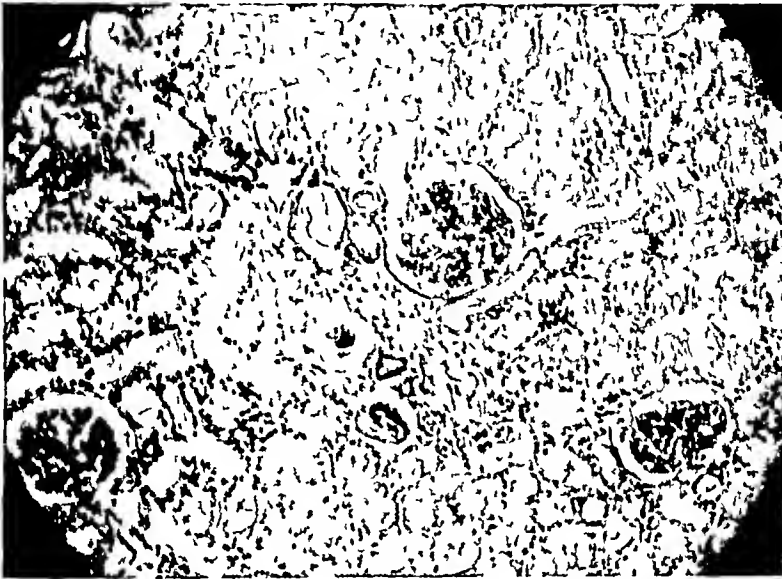


FIG 2

Section of cortical area showing bloodless glomeruli degeneration of convoluted tubules and cast formation in the ascending loop

toxic theory base their conclusions on the fact that after injury to muscles, pigment may be found in the urine and in the kidney. But the findings summarised earlier in this communication indicate that haemoglobin can no longer be considered toxic unless there is also damage to the kidney. Furthermore the condition is seen also when there is no evidence of haemolysed blood or of intravascular pigment [54, 100, 116]. On the other hand it is possible that the investigations of Green and Stoner [82, 83] may have a bearing, for they demonstrated adenosine triphosphate in increased amounts, both experimentally and clinically, in cases of injury, shock, burns, and ischaemia of muscle. It is not yet clear whether such toxin has direct action upon renal epithelium or whether it produces alteration in the renal circulation.

The possibility that this syndrome may be due to changes in renal haemodynamics has been over-shadowed for some years, for it has been shown already that renal failure is capable of demonstration by more delicate kidney tests in shock and in the majority of conditions classified in Table I.

The recent work of Trueta and others [146] has helped to solve this problem. They have shown that when rabbits are shocked by trauma or bleeding, ischaemia of the renal cortical area develops, with vaso-constriction of the renal arteries, thus suggesting that

there is considerable reduction of blood flow causing anoxia of the kidney epithelium and finally cortical necrosis of the kidney. This theory is supported by histological studies. The fact that renal epithelium is susceptible to anoxia is well known [7, 106, 136, 147]. It is important to know, therefore, the period of time during which anoxia must be maintained before such changes become irreversible. This varies from animal to animal. Allen [1, 2] found that rats were sensitive to renal ischaemia lasting no more than two hours. Van Slyke *et al* [147] demonstrated that dogs could withstand ischaemia up to five hours and that the duration of renal ischaemia had a direct relationship to the mortality rate. When ischaemia was maintained for no more than three hours all animals were capable of recovery, although there was urea retention for several days, when the arteries were restricted for four hours there was a 50 per cent mortality rate, and when ischaemia was continued for six hours no animal recovered. On this analogy it is thought that the length of time necessary to produce such changes in the human being may be in the region of eight hours or more. This does not, however, explain the high mortality rate when there is also intravascular deposition of pigment. Yuile *et al* [158], working with rabbits, produced ischaemia by incomplete occlusion of the renal artery, or by sub-lethal doses of sodium tartrate and found that when a non-toxic stroma-free haemoglobin was injected there was significant rise in the mortality rate. We confirmed this work and showed that the histological changes of traumatic uraemia could be simulated closely in rabbits by incomplete occlusion of the renal artery except that cast formation was largely of the albuminous type. We showed also that the mortality rate in rabbits after one hour of occlusion was 20 per cent, after one and a half hours 60 per cent, and after two hours 100 per cent [7]. In subsequent experiments the procedure was repeated and stroma-free haemoglobin was injected intravenously. The mortality rate was not influenced in cases of ischaemia for not more than one hour, but there was significant increase to a mortality of 83 per cent when ischaemia was maintained for ninety minutes [8]. These experiments suggest that when there is shock sufficient to cause irreversible degeneration of epithelium the chances of recovery are materially affected if haemoglobin is free in the circulation, but that when ischaemia is of lesser degree, and there is sufficient normal renal tissue remaining, it is possible for the animal to excrete haemoglobin without further embarrassment of the kidney.

#### CLINICAL RECOGNITION

For the traumatic surgeon it is the ability to recognise, prevent, and treat this condition which is important. The earliest sign is anorexia, accompanied by hiccough, and followed within a few days by copious and effortless vomiting. The tongue is dry. The patient is drowsy and he suffers hallucinations with acute attacks of restlessness. Localised areas of oedema may develop. The two most characteristic symptoms, apart from vomiting, are oliguria and hypertension. It may be difficult to recognise the oliguria unless an intake and output chart is kept because these bear direct relationship to each other even although there may be considerable retention of fluid. Examination of the urine may give no indication as to the severity of illness because the specific gravity remains constant between 1014 and 1018. Excretion of urea is fixed between 0.9 mgm per cent and 1.6 mgms per cent and the pH is held between 5.2 and 6.4. In other cases there may be complete anuria. In the early stages, when shock is severe, the blood pressure may be very low, but as a rule hypertension develops slowly over a period of days, the systolic pressure often exceeding 200 mm of mercury. One of the most remarkable features of the syndrome is the rapidity and height to which blood urea or non-protein nitrogen may rise. The blood urea is always greater than 100 mgms and anaemia is common. Other associated changes are rise in the level of serum potassium and inorganic phosphate, this being accompanied by a fall in the level of serum calcium and serum proteins. There may be reversal of the albumin-globulin ratio

In a previous paper [5] it has been shown that there is also acidosis and hypochloraemia, but this is not necessarily part of the syndrome since it may also be found in any seriously injured patient. In cases where the limbs have been crushed, amputation does not necessarily prevent uraemia, death usually occurs between the sixth and eighth days [100].

### TREATMENT

**Preventive treatment**—It is estimated that from 16 to 19 per cent of deaths from gun-shot wounds are due to traumatic uraemia [100], and that when the syndrome is fully developed the mortality rate may be as high as 90 per cent. Preventive treatment is clearly of great importance. Shock must be combated with all possible speed in order to prevent irreversible kidney changes. Before major operations are undertaken the anaemia and electrolyte water balance must be corrected in order that function may be restored in the kidneys before added strain is thrown upon them. Trueta suggested that change in renal haemodynamics may be prevented by splanchnic or spinal block [144]. Porritt *et al* [130] reported unfavourably on this treatment but success has been achieved by early splanchnic block [86, 87, 135, 137]. When there is limb injury local treatment is important. Patey and Robertson [126] advocated firm bandaging in order to prevent the development of oedema or the release of nephrotoxic substances. Emergency immobilisation is necessary to avoid neurogenic shock.

**Correction of electrolyte balance**—When once the syndrome is established treatment is much more difficult. Correction of the electrolyte balance may not always be successful but nevertheless it should be put in hand immediately [5, 91, 110]. In assessing the quantity of sodium chloride, sodium bicarbonate, or sodium lactate which should be given the formula of Discombe (1943) has given the most consistent results [58]. The calculation is based upon the approximate weight of the patient in kilogrammes, and the plasma level of chlorides expressed as sodium chloride. The amount of salt which is necessary to correct plasma level is estimated by the formula  $\frac{W(590 - X)}{200}$  G, W being the weight of the patient in kilogrammes, X the level of chloride expressed as sodium chloride, and G grammes. The bicarbonate necessary can be calculated by the formula  $\frac{W(64 - Y)}{60}$  G, W being the weight of the patient in kilogrammes, Y the level of CO<sub>2</sub> combining power expressed in vols per cent, and G grammes. In practice this second calculation has not been found necessary unless the level of CO<sub>2</sub> combining power is below 30 vols per cent. Further disturbance of the electrolyte balance may be shown in the fall of serum calcium and the rise in serum potassium. These changes together may cause serious cardiac complications. If the level of potassium exceeds 40 mgms per cent there is danger of fibrillation and death [91]. Sudden death is often observed in cases with oliguria [113]. For this reason care should be taken to avoid sudden and unnecessary movements of the patient. The use of a gastric tube with continuous suction is valuable [91] not only because it avoids the unnecessary distress of vomiting but because it reduces the level of serum potassium, potassium salts being excreted freely in the gastric juices. The calcium level is corrected by intravenous injections of calcium gluconate.

**Management of water metabolism**—Control of fluid intake is often more important than correction of the electrolyte balance. In consequence of oliguria there is accumulation of fluid within the body with oedema of the lungs and overloading of the circulation. The amounts of fluid needed in twenty-four hours can be estimated by adding the volume of urine and vomit excreted the previous day to the amount of fluid presumed lost by the lungs and sweating (which may usually be taken as 1000 millilitres per day [113]). In order to ensure that the fluid is absorbed it should be given in the form of an intravenous drip. Although this may lead to difficulty in introducing sufficient sodium chloride solution, as much as 4 per cent can be given without harm provided that the plasma level of sodium chloride does not exceed 475 milligrammes per cent.



**Use of sodium sulphate**—It has been suggested recently that the administration of sodium sulphate is of benefit [124] but former impressions proved disappointing. It is submitted that sodium sulphate should be used only for the initial stages of sulphanilamide poisoning before kidney tubular damage has occurred. This may cause sudden diuresis with the possible ejection of crystalline deposits of sulphanilamide or haemoglobinuric casts.

**Artificial kidney**—This new treatment has aroused much interest, it is designed to remove the toxic products resulting from renal failure and to give time for the kidney to regenerate. A sufficient number of cases has now been published to show that the method warrants further study [97]. At the same time it must be recognised that the dialysing fluid is of the simple electrolyte water type which allows passage of water into the circulation of the patient with consequent overloading. Furthermore the machine is bulky. In a paper shortly to be published it is hoped to show how these difficulties have been partly overcome.

**Peritoneal dialysis**—There are two dangers in the technique of peritoneal dialysis in which large quantities of sterile isotonic fluid are injected into the peritoneal cavity and subsequently extracted. Not only is it difficult or impossible to withdraw all the fluid, but it is difficult to avoid peritonitis due to contamination of the fluid with pathogenic organisms.

**Renal decapsulation**—Surgeons have advocated bilateral renal decapsulation with the object of relieving increased intrarenal pressure. The procedure is said to be performed easily and often to be followed by diuresis [128]. This was not confirmed by Styron and Leadbetter [141] who performed decapsulation of one kidney and by ureteric catheterisation demonstrated clearly that there was no difference in function of the two kidneys, either in the acute or in the convalescent stages. It would seem that much more justification is needed for the adoption of so heroic a measure in patients who are desperately ill.

### SUMMARY

Traumatic uraemia is of particular significance to orthopaedic surgeons in so far as this complication is responsible for high mortality in cases of severe injury, crushing injury, traumatic shock, gun-shot wounds, incompatible blood transfusions, and the misuse of tourniquets. In this contribution the association between muscle injury and renal failure is reviewed.

The syndrome of the "crush kidney," which at first was thought to be the result of deposition of myohaemoglobin in the renal tubules, is almost certainly due to the association of many factors, all of which lead to alteration of the renal circulation and renal ischaemia.

Certainly the combination of ischaemia of the kidney with deposition of pigment and haemolysis of blood causes a high mortality in animals, and it is believed that this may account for the serious prognosis in human cases where there is both shock and haemolysis.

Disturbance of water balance, allergic phenomena, and chemical nephrotoxic action are also discussed. The pathology is considered together with significant changes in the blood chemistry.

A plea is made for early recognition of this clinical syndrome with its characteristic features. Important aspects of treatment are discussed. The dangers of excessive intravenous infusion are emphasised.

Closer investigation and further research promise to throw light on the more accurate localisation of function in the nephron, to add to our knowledge of traumatic arterial spasm, and to explain many orthopaedic problems which hitherto appeared insoluble.

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tightening of the capsular fibres so that passive flexion of the humerus is brought to a stand still. Show also that previous lateral or medial rotation of the humerus (or converse rotation of the scapula) has a similar effect.

**The experiment analysed**—We all know that any part of the humerus distal to the shoulder joint moves along a curved line—the arc of swing. The sum of all the possible arcs of swing constitutes a curved surface—the “sphere of movement”. This surface is not actually part of a true sphere but there is no loss of generality in considering it to be so.

Fig 7 is a picture of a sphere. Its “south pole” is shown as well as a portion of its equator (WE) and half of two meridians (ES, WS) which are 90 degrees of longitude apart. Consider the displacement of a small arrow upon the surface of this sphere. To begin with it is placed pointing westwards at the south pole. It is then made to slide along the meridian SW until it reaches the equator. It is then made to slide eastwards along the equator until it reaches the original meridian ES. Look again at the arrow shown at the south pole. Imagine *this* arrow to be slid northwards along the meridian SE. It is clear that the arrow at E will be rotated 90 degrees in a clockwise direction compared with the arrow which has been moved up directly from S. It is also clear from the picture that this rotation has been accomplished during the simple sliding movement from W to E, for the arrow would show no rotation if it were moved back from W to S. This example is a very simple case of the effect of two successive displacements of a rigid body upon a curved surface, and will repay careful study.

The arrow can be moved from S to E in two ways: either along the direct path SE, or along a two-leg pathway SW–WE, the two legs having only one point (W) in common. Such a two-leg pathway will be called a *diadochal* path, and the corresponding movement a *diadochal* movement (Gr *diadochos*, successive). The arrow-sphere experiment is a special case of the working of a general law, namely that every diadochal movement is accompanied by rotation of the bone about its long axis, unless of course some counter-force is applied to prevent the rotation. Let us call this rotation the *conjunct rotation*, since it is mechanically conjoined with diadochal movement. We have to ask what is its nature, and what is its amount?

The answers to these questions are contained in a general theorem which has been stated and proved elsewhere (MacConaill 1946b). This takes account of all possible kinds of surface, and all possible kinds of movement upon them, the “parallelogram of forces” is a minor corollary of it. The most general form of the theorem is needed for an understanding of the working of the diverse types of articular surfaces, but it is not necessary for the purposes of this paper. What is necessary is to consider that part of the theorem which deals with convex surfaces. It can be illustrated in the particular case we are now considering.

First, then, examine the nature of the rotation. Look again at Fig 1. The diadochal path SW–WE is a clockwise path, the conjunct rotation of our arrow was a clockwise rotation. Had the path been SE–EW, the conjunct rotation would have been anti-clockwise—that is, it would have been of like sense to the sense of the new diadochal path. Expressed as a generalisation: *the conjunct rotation associated with a diadochal movement is clockwise or anti-clockwise according as the diadochal movement is clockwise or anti-clockwise respectively*. Thus, flexion of the right shoulder followed by backward swing of the arm is, from the subject's point of view, a clockwise movement. So also, from his point of view, is lateral rotation of the arm. Again, abduction of the arm at the right shoulder followed by forward swing of the

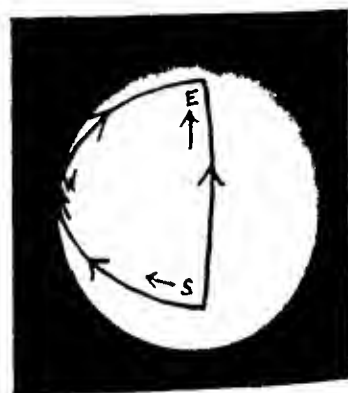


FIG 7

Diadochal movement is accompanied by rotation of the bone about its long axis.

arm is from the subject's viewpoint, an anti-clockwise movement. In this case the conjunct rotation is anti-clockwise—that is, medial rotation of the arm.

Secondly, what is the amount of the conjunct rotation? The precise solution of this problem is of theoretical rather than practical interest, but it can be understood easily from Fig. 1. In this figure, the lines SW, WE, and ES cut each other, two by two, at right angles. The whole figure SWE is a spherical triangle, and the sum of its contained angles is three right angles. In this case the conjunct rotation was 90 degrees—that is to say three right angles less two right angles. This result can be generalised: *the magnitude of conjunct rotation is equal to the difference between two right angles and the sum of the angles of the triangle formed by the two "legs" of the diadochal path and the "direct" path between the first and last positions of the bony point considered*. In practice, this magnitude is equal to the angle between the plane of the "direct" swing and the plane of the first stage of the diadochal path. The reader is referred to the paper cited above for the justification of the approximation. It is not self-evident.

### THE PRACTICAL SIGNIFICANCE OF CONJUNCT ROTATION

The phenomenon of conjunct rotation has a bearing upon three matters of interest to orthopaedic surgeons: 1) the actions of individual muscles and muscle groups, 2) the movements studied in industrial physiology, 3) the diagnosis and therapy of affections of the limbs. Detailed consideration of the first and second topics must be deferred but the general significance of the law of conjunct rotation is clear. The example of the shoulder joint will serve.

When the arm hangs by the side the long axis of the limb—that is to say the axis of medial and lateral rotation—coincides with an axis normal or "perpendicular" to the earth. When the limb is swung first forwards and upwards, and then backwards, the second or backward movement is actually a swing around that vertical axis. We have seen that lateral rotation is thereby produced. In other and more general words: *the result of movement around a standard axis is independent of the particular muscle mechanism by which that movement is brought about*. When the arm hangs by the side lateral rotation is largely the business of teres minor, when it is in a horizontal plane it is largely the business of the back part of the deltoid muscle. The cerebro-cortical "picture" is realised by one set of spinal nerves in one position of the limb, and by another and largely different set of spinal nerves in another position of the limb. The proof of this statement lies in the fact that the teres minor is capable of adding to conjunct rotation by active contraction at a rate exceeding that which it requires for "taking up its slack". The taking up of slack is controlled sub-cortically, whereas the extra adjunct contraction is a cortical affair. This concept leads at once to differentiation between two types of synergy, and two types of antagonism.

The simple backward swing of a flexed humerus requires synergic relaxation of the medial rotators if conjunct lateral rotation is to be permitted. There is no consciousness of that lateral rotation, not even in the mind of this writer when he performs it! There is none of that "sense of effort" to which Arthur Lynch has directed attention (Lynch 1923) and which is the accompaniment, however muted, of cortical activity. Furthermore, diadochal lateral rotation of the arm can be carried out passively upon a completely relaxed subject, in whom the cortex is inhibiting rather than relaxing the musculature. The synergic relaxation in conjunct rotation must, therefore, be carried out by a nervous mechanism which differs in part from that which comes into play in adjunct or "active" rotation. Now the "rotator" muscles of descriptive anatomy are deep muscles, and conversely. Hence it may be possible to test spasticity of the deep muscles by carrying out passive diadochal movements and returning the limb to the same plane as that from which it started, inability to maintain the imposed rotation would be a certain sign of spasticity.

**Rehabilitation exercises**—The phenomenon of conjunct rotation appears to offer a means of exercising muscles which are too weak to raise the limb as they should normally do. Since diadochal movement demonstrates that the action of flexors, extensors, abductors, and adductors includes a rotator component, it follows that rotations carried out actively or passively, in the bed or convalescent chair, will call forth contractions of all the muscle fibres of the joint which is moved. There is no need to enlarge upon this device, it is no doubt widely used already, and all that this writer wishes to show is that such simple exercises have a mechanically rational basis.

#### SUMMARY

- 1 Two successive movements at a joint, if not in one and the same plane, constitute a diadochal movement
- 2 Diadochal movements impose conjunct rotation upon the bone which has been moved. This may be countered by a rotation of opposite sense
- 3 All muscles of a given joint are, therefore, rotators in some degree
- 4 Upon the basis of these principles diagnostic and therapeutic suggestions are made

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# POTT'S DISEASE OF THE SPINE WITH RUPTURE OF THE AORTA

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Death as the result of tuberculosis of the spine occurs with sufficient frequency to call for no special comment, but the clinical histories and causes of death in two patients recently treated in this hospital for tuberculous disease of the spine were of considerable interest. In the first case the diagnosis of tuberculous disease was proved, but in the second case there was some doubt.

**Case 1** Mrs E S, 22 years of age, was first seen by the local tuberculosis officer in 1943. Ulcerating tuberculous glands in the neck, previously treated in January 1942 by surgical excision and deep X-ray therapy, had subsequently broken down. Further conservative treatment had been recommended but had been refused by the patient. She was next seen in June 1945 with tuberculosis of the spine involving the tenth and eleventh dorsal vertebrae and the intervening disc. There was collapse of the bodies of both vertebrae.



FIG 1

Case 1 Radiographs June 1945 showed a large mediastinal abscess pushing the trachea forwards



FIG 2

Case 1 Barium swallow June 1945 shows leakage from the oesophagus into the mediastinum

(Fig 3) Routine X-ray examination of the chest at that time showed a large mass in the superior mediastinum pushing the trachea forwards (Fig 1). This was thought to be a collection of tuberculous glands which was breaking down, or alternatively a paravertebral abscess arising from a tuberculous lesion in the upper dorsal spine, but there was no radiographic evidence of bone destruction at this level. The abscess ruptured into the oesophagus and caused mediastinitis. At that time the patient was very ill, there was pyrexia with a



temperature of  $101^{\circ}$ – $102^{\circ}$  F. She was treated on a plaster bed and her general condition improved. Radiographic examination after a barium swallow showed that the barium leaked out of the oesophagus and tracked downwards in the mediastinum (Fig 2).

In March 1946 she was admitted to this hospital. Her general condition was poor. She had a hectic flush and evening pyrexia. She was thin and wasted, and her appetite was poor. There were scars of healed sinuses in the right side of the neck and a few small hard glands. No abscess was palpable and there was no paraplegia.

Immobilisation on a plaster bed and open air treatment was continued and although her general condition remained poor, and she developed oedema of the ankles, the spinal disease became quiescent and there was radiographic evidence of sound fusion of the affected



FIG 3

Radiographs June 1945 show tuberculosis of the spine involving D 10-11 but there is no evidence of a spinal lesion at the level of the mediastinal abscess or the oesophageal leak.



FIG 4

Radiographs, November 1946, show that the original lesion at the level of D 10-11 has healed but there is now destruction and collapse of the eighth dorsal vertebral body.

vertebrae. Repeated X-ray examination of the upper dorsal region failed to show evidence of bone disease and the mass which had previously been noted was no longer evident. In November 1946 an abscess could be felt in the right loin, foul smelling green pus was aspirated and streptococcus viridans was grown on culture of the pus. No tubercle bacilli were found on film examination and no positive result followed inoculation into a guinea-pig. Later radiographic examination showed active disease of the body of the eighth dorsal vertebra with marked destruction and collapse (Fig 4). The abscess refilled and was aspirated once more but nevertheless a sinus formed. There was marked anaemia (haemoglobin 30 per cent, red cells 1,800,000, colour index 0.85). Three transfusions of blood, one pint each, were given. Diarrhoea was persistent but there was no melaena and no frank blood in the stool.

On December 6, 1946, the patient suddenly felt faint. She passed three pints of blood per rectum. Shortly afterwards she passed another pint of blood. Then she died. There was no vomiting and no blood appeared in the mouth.

*Post-mortem examination* At post-mortem examination a little free fluid was found in the peritoneum. There was a large abscess in the right loin extending to the mid-dorsal region. There was no dilatation of large or small intestine, and no blood within the gut, but there was a little stuning of one part of the ileum. The stomach contained one and a half pints of blood, the pylorus being tightly contracted. A few tubercles were found on the walls of the small intestine. The spleen was small. The liver and kidneys were normal. In the chest a few pleural adhesions were present but there was no active disease in either lung. The heart was normal.

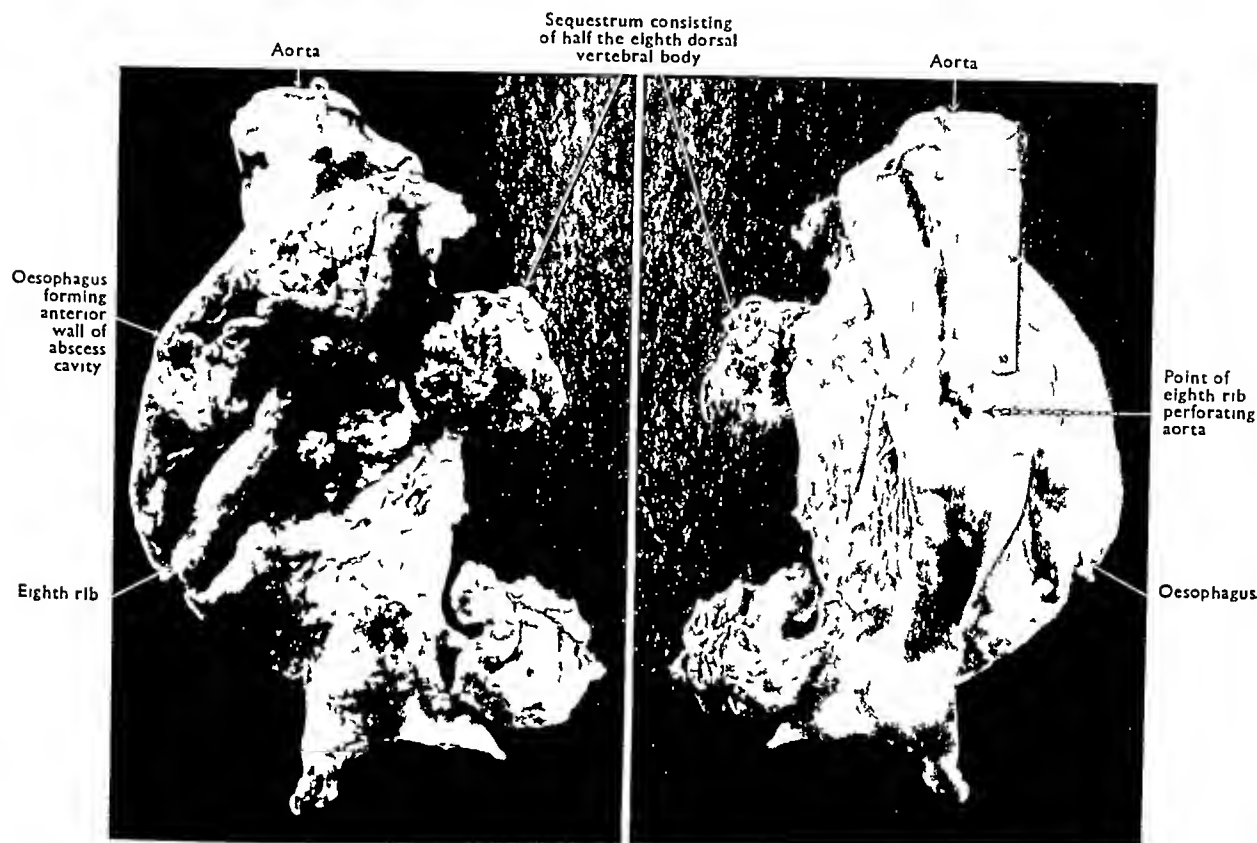


FIG 5  
Posterior View

FIG 6  
Anterior View

Post-mortem specimen showing mediastinal abscess cavity (Fig 5) the anterior wall of which is the remains of the oesophagus with the eighth rib sprung forwards in consequence of erosion of its neck so that it has perforated the oesophagus and the aorta (Fig 6). The large sequesterum consists of half the eighth dorsal vertebral body; it acted as a ball-valve blocking the upper oesophagus and thus preventing haematemesis when the aorta ruptured.

At the level of the eighth dorsal vertebra, and extending upwards for three inches, was a firm fusiform mass in which the oesophagus and posterior wall of the aorta were involved. There were many surrounding adhesions. This mass proved to be an abscess, the posterior wall of which was formed by carious vertebral bodies and the anterior wall by the remains of the oesophagus, which was almost unrecognisable, and the aorta. Perforating the posterior wall of the aorta was the proximal end of the eighth rib, eroded through its neck by disease, thus producing an aortic-oesophageal fistula (Figs 5-6). The abscess, measuring three inches long by two inches wide, had a thick fibrous wall. Within it was a free sequesterum, the size of a walnut, consisting of the anterior half of the eighth dorsal vertebra. The whole of this body was destroyed and there was also erosion of the bodies

of the sixth and seventh dorsal vertebrae. The earlier lesion of the tenth and eleventh dorsal vertebrae was healed, but the bony fusion was less sound than had appeared to be the case from radiographic examination.

*Comment* This case presents several features of interest.

1 In the first place, early excision of tuberculous glands in the neck appears to have disseminated the disease and accounted for a metastatic focus of tuberculous infection in the tenth and eleventh dorsal vertebrae.

2 Infection of the eighth dorsal vertebra was due to direct spread of infection from the abscess, recognised radiographically in the superior mediastinum, which was originally a tuberculous abscess from mediastinal glands but became secondarily infected with streptococcus viridans from the oesophagus, which at that time appeared intact. No evidence of bone infection in this region was found until eighteen months after the abscess was first observed.

3 The mediastinal abscess subsequently ruptured into the oesophagus, and possibly into the mediastinum as well. Although the appetite of the patient was poor there was no dysphagia, liquid and solid foods were swallowed easily. The post-mortem findings show that the food must have passed actually through the abscess cavity.

4 The next unusual occurrence was erosion of a rib through its neck so that the rib sprang forward and perforated both the wall of the oesophagus and the aorta, thus causing death.

5 Finally the manner of death presents problems for consideration. It would seem reasonable to expect that if a communication was established between oesophagus and aorta, haemorrhage would occur through the mouth. This, however, was not the case, the blood travelled downwards through the intestine and was passed per rectum. Clearly some valvular action had taken place at the upper end of abscess which closed the oesophagus. It is suggested that the large sequestrum lying free in the abscess may have been forced upwards by the influx of blood, thus blocking the oesophagus at its upper end and acting as a ball-valve. It is also interesting that although the stomach was full of blood there was no trace of blood, apart from a little staining in the ileum, from the pylorus to the anus.

**Case 2** Mr W R, aged 37 years, was first seen in June 1944 complaining of pain in the back. Radiographs showed a destructive lesion of the intervertebral joint between the twelfth dorsal and first lumbar vertebrae which was diagnosed as tuberculous (Fig 7). He was treated in recumbency on a spinal frame for sixteen months and was discharged from hospital in November 1945 wearing a back support.

In April 1946 it was found that the disease had extended (Fig 8) and antero-posterior radiographs showed a soft tissue shadow which was suggestive of abscess formation. Further in-patient treatment was recommended but this was refused.

In January 1947 he was readmitted and put on a frame. His general condition was fairly good and there was no pain in the back, no kyphosis, and no palpable abscess. Radiographs showed that the area of destruction had increased. Moreover, an extraordinary hollowing of the twelfth dorsal vertebral body had developed (Fig 9) and the possibility of neoplasm of the spine was suspected. Punch biopsy in October 1947 showed no evidence of tumour. There was pus, with cellular debris, but no micro-organisms, and cultures remained sterile. The Wassermann and Kahn reactions were found to be strongly positive and a course of anti-syphilitic treatment was instituted.

In November 1947 the patient complained of pain in the left loin, of sudden onset, accompanied by nausea, vomiting, and a sensation of fullness in the abdomen. Clinical examination revealed a large, firm mass in the epigastrium extending under the left costal margin with an upper limit which could not be reached. The swelling pulsated but it was difficult to determine whether the pulsation was expansile or transmitted. Radiographs



FIG 7  
June 29 1944

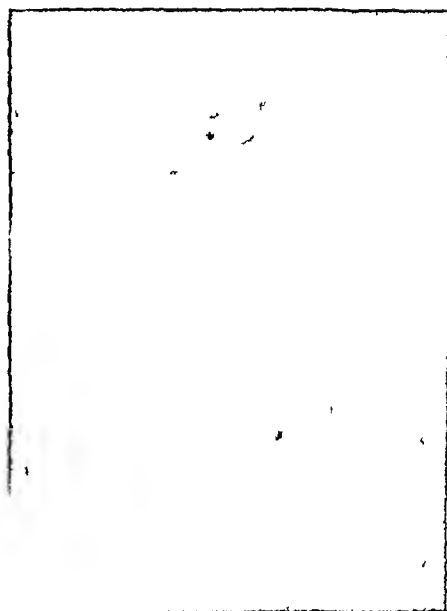


FIG 8  
April 4 1946



FIG 9  
August 12 1946



FIG 10  
December 2, 1947

Case 2 A destructive lesion at the level of the D12-L1, was diagnosed as tuberculosis (Fig 7). During the next ten months the disease extended (Fig 8). Unusual hollowing of the twelfth dorsal vertebra then developed (Fig 9). Two months later typical aneurismal erosion was obvious (Fig 10).

showed still further destruction of the front of the vertebral bodies which by then was characteristic of aneurismal erosion (Fig 10) The question remained whether the erosion was due to an aneurism of the abdominal aorta, coincident with a tuberculous or gummatous lesion of the spine which happened to be at the same level, or whether vertebral erosion might be due to the transmitted pulsation of a tuberculous spinal abscess If the latter alternative was correct the abscess was obviously approximating so closely to the abdominal aorta that there was danger of erosion of the wall of the artery with secondary rupture into the abscess cavity such as had occurred in the first case In this event evacuation of the abscess through a posterior approach was desirable, on the other hand such a procedure was not to be undertaken until the surgeon was sure that he might not open an aneurism! An abdominal laparotomy was therefore carried out and the mass was found to be a large aneurism of the abdominal aorta extending above the diaphragm The patient made an uneventful recovery from the operation On January 12, 1947, he complained of sudden dyspnoea and pain in the left side of the chest He died in twenty minutes

*Post-mortem findings*—Post-mortem examination showed that the left pleural cavity was full of blood The arch of the aorta showed extensive syphilitic aortitis but no aortic incompetence The heart was normal but there was excessive fluid in the pericardium A large mass, extending through the diaphragm, proved to be a very large aneurism of the aorta extending from the level of the third lumbar vertebra to that of the seventh dorsal vertebra, lying chiefly in the left side but also extending to the right side of the mid-line below the diaphragm In the intra-thoracic part there was a perforation rather more than two centimetres in diameter The wall of the aneurism was very friable indeed It was not opened The whole specimen including the vertebral column was removed in one piece and preserved in fixative

Most unfortunately, two days later the hospital was destroyed by fire The pathological department and this particular specimen were lost No dissection has been possible

*Discussion*—Owing to loss of the specimen the diagnosis cannot be stated with certainty, and even the correct sequence of events is left in some doubt The initial radiographs (Fig 7) suggested that in the first place there was a simple destructive lesion of the spine which was probably tuberculous but might have been gummatous in origin Later radiographs showed striking increase in the destructive process, with change in its nature from that of a simple intervertebral inflammatory lesion to that of typical aneurismal erosion It is believed that a syphilitic aneurism of the aorta developed at a later date than the spinal lesion, and because the bone behind it was softened by incompletely healed disease the aneurism caused secondary pressure erosion It is interesting to note that although the aneurism extended over eight vertebral bodies only those involved in disease showed erosion

Re-examination of the antero-posterior radiographs taken in September 1946 shows evidence of two soft tissue shadows, one overlying the other, presumably one was due to the spinal abscess and the other to the aneurism The radiographs taken three months later, and two weeks after the sudden onset of pain in the left loin, show loss of the clear-cut shadow on the left side, a more fusiform shadow on the right, and a new shadow of a large mass in the left chest It may be that the sudden attack of pain was due to rupture of the aneurism into the abscess cavity, with subsequent upward extension of a false aneurism into the mediastinum which finally ruptured into the left pleura

Unfortunately there are a number of points which cannot be determined with certainty

- 1) Was the bone lesion of the spine tuberculous or syphilitic?
- 2) Was the aortic aneurism secondary to the spinal lesion or was it coincidental?
- 3) Did the aneurism rupture into an abscess cavity and into extra-peritoneal tissue causing a false aneurism, or was it a true fusiform aneurism which increased rapidly in size until it ruptured?

We are indebted to Sir Reginald Watson-Jones for permission to report these cases and to Dr Paton Phillip Tuberculosis Officer for Cambridgeshire for early clinical details and radiographs of the first case

# CONGENITAL ABSENCE OF THE HUMERAL HEAD

## Report of Two Cases

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The purpose of this article is to present clinical data, review the literature, and speculate as to the origin of a rare condition. The first case here recorded had been passed over with the remark that "the condition is probably congenital." Attention was aroused when a second case was seen a few months later.

### CLINICAL MATERIAL

**Case 1** B. S., aged 26 years—Of normal appearance with powerfully developed muscles. Abduction and medial rotation movements of the right shoulder joint were almost completely lacking. The right humerus was ten inches long and the left eleven and a half inches long. There was no history of injury and no other explanation of the condition which had been present as long as the patient could remember.

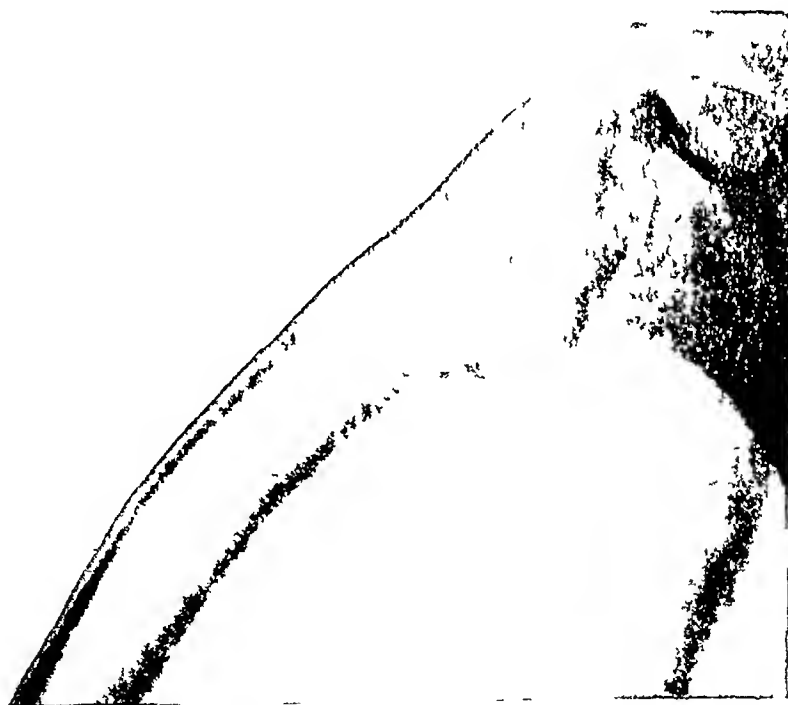


FIG. 1

Case 1. Congenital absence of humeral head showing the flat surface of the humerus, the well-developed greater and lesser tuberosities, and the outward bow of the shaft of the humerus.

Radiographs showed that in place of the usual head of the humerus there was a flat surface with a small central boss projecting about 4 mm (Fig. 1). The articular surface was twice the length of that of the glenoid. The greater and lesser tuberosities were well developed and the inter-tubercular sulcus was seen clearly on the outer surface of the bone. The shaft had a distinct outward bow with its summit at the deltoid insertion. The cortex was abnormally thick and dense on the outer side but it was thin on the inner concave side. The glenoid was flattened with a slight concavity opposite the central boss of the humerus. A tubercle was present above the glenoid. The coracoid process was developed normally. The left shoulder joint was normal.

**Case 2** Z M K , a healthy Sepoy, aged 28 years—This patient stated at once that disability of the shoulder joints had been present since childhood but not to such a degree as to affect his capacity as a fighting man. He was somewhat indignant that his fitness for service should be questioned. On examination he was found to be normal except for the upper arms and shoulder joints. He was well developed. Both upper arms were short but the forearms were of normal length (Fig 2). The right humerus measured nine inches and the left ten and a quarter inches. Judging by the position of the lateral condyles there was lateral rotation deformity of the right humerus. Abduction was limited by bone block (Fig 3). *Radiographs* showed gross deformity of both humeral heads and glenoids. As in the first case the humeri were shortened and bowed outwards and the cortex was thicker on the convexity and thinner on the concavity. In order to gain information as to the shape of the joint surfaces radiographs were taken in the position of adduction, abduction and lateral rotation and also from the axillary view. The findings were

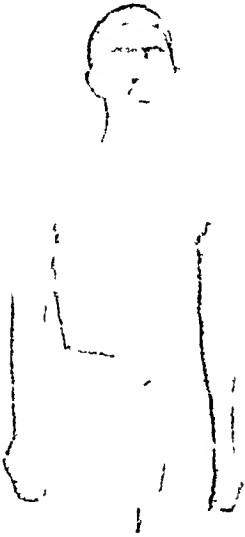


FIG 2



FIG 3

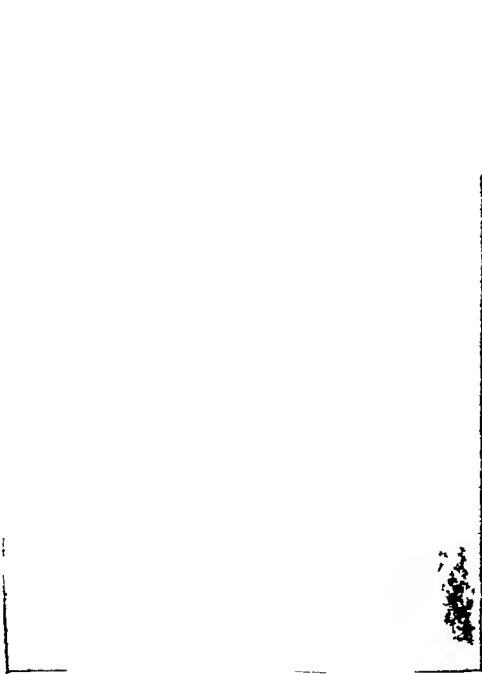


FIG 4

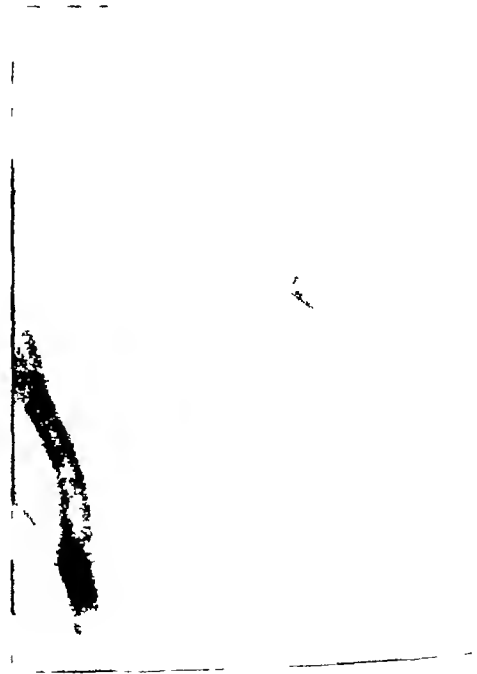


FIG 5

**Case 2** Bilateral congenital absence of the heads of the humerus. Note the shortening of the upper arms (Fig 2). Abduction movement of the shoulder is limited by bone block (Fig 3). In both arms the shaft of the humerus is bowed; there is alteration of cortical density and the glenoid boss is a convex protrusion fitting into a concave humeral head (Figs 4 and 5).

*Right shoulder*—The glenoid was represented by a boss of bone at the upper end of the axillary border of the scapula. Above and below this rudiment separated from it by well-defined grooves could be seen the supraglenoid and infraglenoid tubercles; these structures and the coracoid process appeared to be of normal size. The upper end of the humerus was represented by four bone elevations surrounding a concavity, the elevations representing the greater tuberosity, the lesser tuberosity, and the rather exaggerated facets of the infraspinatus and teres minor muscles. The shaft of the humerus showed bowing and alteration of cortical density (Fig. 4). The axillary view showed that the glenoid boss was a convex protrusion fitting into a concave humeral head. *Left shoulder*—The glenoid boss was larger than on the right side and the humeral joint surface was more shallow and more vertical. Its lower lip was composed of dense bone and was pressed down. The supraglenoid tubercle was not differentiated. The lesser tuberosity was more pronounced than in the right humerus but the greater tuberosity and the bowing, thickening and trabeculation of the shaft were similar (Fig. 5). An axillary view showed similar reversal of the ball and socket arrangement of the joint.

### REVIEW OF LITERATURE

Extensive search of the literature has disclosed only six cases with deformity similar to that now described. Lewin (1931) reported two cases. The first had bilateral but asymmetrical deformity. On one side there was a convex glenoid, and a concave humeral head, suggesting absence of only part of the capital epiphysis (Fig. 7). On the other side the joint was formed of a humeral surface which was slightly S-shaped, filling a corresponding glenoid surface (Fig. 6); there was no vestige of the head and the glenoid was more developed than its fellow. Lewin's second case showed unilateral deformity, very similar to that of his first case, but it was complicated by ankylosis of the elbow and Madelung's deformity (Fig. 8). Walter Muller (1939) described three cases with deformities of varying degree (Figs. 9, 10, 11). All three patients had other congenital bone and joint deformities. Brailsford (1944) recorded another case. No details were given but it will be seen from the radiographic tracing that the appearances are similar to those of Lewin's first case (Fig. 12).

### DISCUSSION

This group of cases represents varying degrees of a typical but hitherto unrecognised deformity of the shoulder joint. The essential features are complete or incomplete absence of the humeral head with a rudimentary glenoid. The deformity may be unilateral or bilateral, it may be isolated or it may be one of a number of deformities in the same patient. It is associated with relatively slight disability. Both patients whose cases are now recorded fought as combatants through the 1945 Burma campaign. The ball and cup arrangement of the shoulder joint is reversed or it is replaced by a saddle-shaped articulation. There seems to be correspondence between the degree of capital deficiency and the state of development of the glenoid (Muller's three cases—Figs. 9, 10, 11). It appears that lack of the capital epiphysis, or of its cartilaginous and precartilaginous stages, causes corresponding lack of the upper epiphysis of the glenoid-complex while the main body of the glenoid continues to develop.

These observations suggest that the defect occurs at a very early stage of embryonic life and that it is due to failure of development of the tissue in which the capital epiphysis should form. The observation that centres developing late and outside the joint capsule are present and well formed, while those developing early and inside the capsule are not present, or are present only in rudimentary form, also indicates that the defect occurs in the early period of development of the primitive joint.

Further support for this hypothesis is gained from consideration of the experimental work of Murray, Fell, and Robison. Murray (1926) showed that joints develop characteristic shape even when grafted elsewhere so that they are remote from the normal influence of contiguous structures. Clearly the general form of a joint is determined by intrinsic influences, although structural details may be the result of "mechanical" forces. Fell and Robison (1929) came to similar conclusions. The problem as to how two opposing rudiments, developed



from a common mesodermal mass, are able to separate and become movable and yet be interdependent and complementary, was considered by Fell and Cantì (1934) using Cantì's technique of cinematography in observing and recording *in vivo* the development of tissues (1928) Fell and Cantì showed that joint formation is not caused by the presence of a layer of non-chondrogenic tissue across the site of the future articulation as suggested by the studies of Murray (1926) and Warren (1934) These studies demonstrated that the avian limb bud is a mosaic system and suggested that separation of the articular surfaces might be an expression of this already existing mosaic Fell and Cantì, in the same report, produced

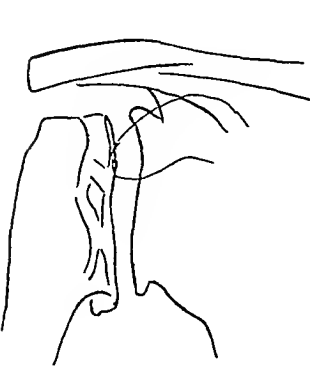


FIG 6  
Lewin's first case—right

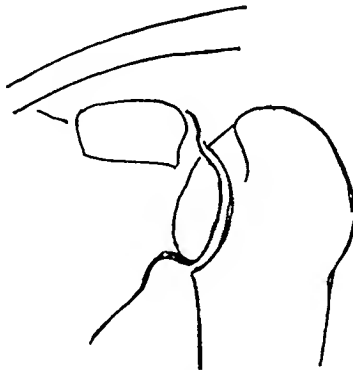


FIG 7  
Lewin's first case—left



FIG 8  
Lewin's second case

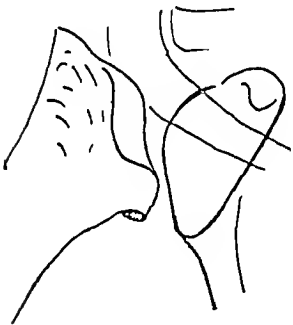


FIG 9  
Muller's first case

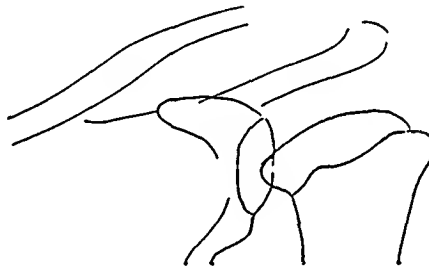


FIG 10  
Muller's third case

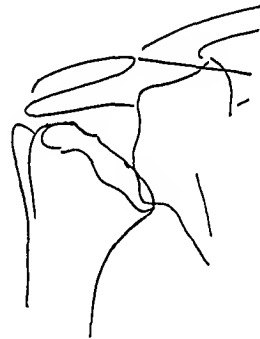


FIG 11  
Müller's second case



FIG 12  
Brailsford's case

evidence for important conclusions 1) The earlier stages of joint formation can proceed in the complete absence of muscular action and of nerve and blood supply 2) Joint formation can take place in the absence of the presumptive joint region 3) Joint formation in the absence of the presumptive joint tissue is controlled by two factors—(a) the amount of tissue removed, (b) the degree of development of the blastema up to the time of operation 4) The articular ends of the long bones cannot develop their normal shape after removal of the presumptive articular tissue

From these considerations it may be supposed that the deformity under consideration arose at the presumptive stage, since only those parts entering into the formation of the primitive joint appear to be affected Extra-capsular structures developed normally except

for minor variations which may be ascribed to altered mechanics. At a very early stage, when the primitive joint had just begun to form, an accident occurred which altered the process of separation in the mesenchyme to form the articular ends. The brunt of force of the accident seems to have fallen upon the humeral head, because in all these cases the glenoid is at least present in rudimentary form, whereas the complementary head of the humerus is seriously deficient in every case. When the cases are set out in order it is seen that the degree of development of the glenoid bears inverse relationship to the extent of humeral defect. If the humeral defect is minimal, the glenoid is well formed, if the humeral element is missing completely, the glenoid is a mere rudiment.

The presumptive joint stage appears to have been well advanced when this unknown factor exerted its influence, causing virtual removal of the caput area and leaving the glenoid without possibility of developing its normal shape. If this is a true reading of the picture, these cases present clinical evidence in support of the conclusions reached experimentally by Fell and Canti.

That the damage is inflicted on the shoulder alone, or only a few joints, might suggest that the accidental factor was present for a limited time which was coincident with formation of the presumptive shoulder joint. But it would appear also that some parts of the body may be more sensitive than others even when exposed simultaneously, and this would account for unilateral cases.

It is possible that the cases collected here on the basis of similar radiographic appearances in the shoulder may not form a true group, because they may not have a common cause. The clinical evidence of similar appearances is, however, supported strongly by experimental data, and it seems reasonable to accept these cases as a group which show a congenital deformity of the shoulder joint, hitherto unrecognised.

### SUMMARY

- 1 Two cases of an unrecognised congenital defect of the humeral head are described and the cause is discussed.
- 2 Only six cases with similar radiographic appearances could be collected from the literature. In most of these cases other skeletal deformities were present, whereas in those now reported only the shoulder was affected.
- 3 Examination of radiographs suggests that the main deformity consists of lack of development of the capital epiphysis of the humerus.
- 4 Consideration of the cases, together with experimental data from the studies of Fell and Canti, suggests that the time in development at which the fault occurred was the presumptive joint stage, just when the articular rudiments had separated.
- 5 A "nociferous agent," acting only for a limited period, and only on certain tissues, is postulated.
- 6 It is suggested that the defects recorded should be recognised as a group of congenital deformities of the shoulder joint.

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## NAIL IN THE SKULL

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A male Chinese, aged thirty years, was on his way to Court to answer a charge of attempted suicide. He sat on the roadside. He took a large nail in one hand and a brick in the other. He hammered the nail into his head. No symptoms developed and he went on his way. But the next day, because a large nail was still projecting from his skull, he was admitted to the Singapore General Hospital. Radiographic examination showed that the nail had been driven accurately through the mid-line (Fig 1). A surgeon decided that although there were still no symptoms the nail should be removed. Immediately he did so there was profuse haemorrhage from the longitudinal sinus and the patient died.

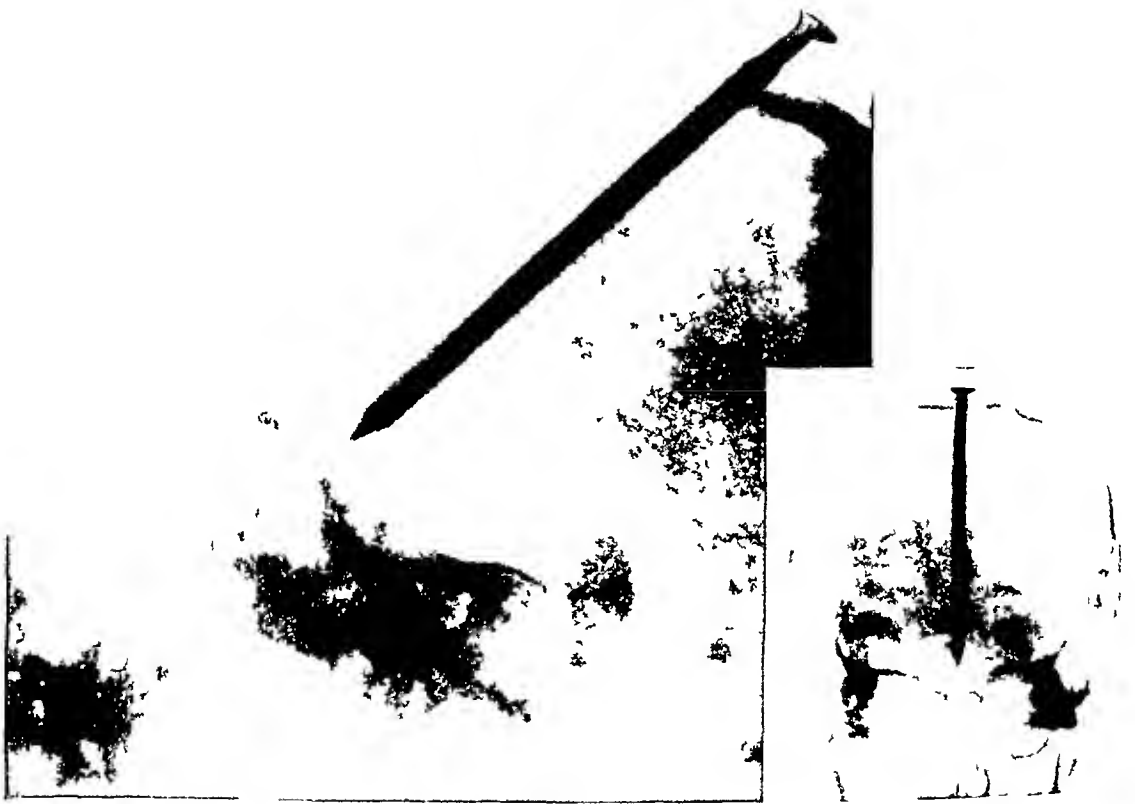


FIG 1

A male Chinese drove a nail into his own skull with a brick

I have radiographs of a second case in which a rather smaller nail had been driven into the mid-line of the skull but unfortunately no clinical history is available.

Another case is recorded. "Sisera lighted down off his chariot and fled away on his feet. And Jael went out to meet Sisera and said unto him, 'Turn in, my lord, turn in to me, fear not.' And when he had turned in unto her into the tent, she covered him with a mantle. Then Jael, Heber's wife, took a nail of the tent and took an hammer in her hand, and went softly unto him and smote the nail into his temples and fastened it into the ground, for he was fast asleep and weary. So he died."

## 2 OSTEOPETROSIS

### Osteopetrosis generalisata, Marble bones

#### Albers-Schonberg's disease, Osteosclerosis fragilitas generalisata

H A THOMAS FAIRBANK, LONDON, ENGLAND

The condition described by Albers-Schonberg in 1904, and to which Karshner (1926) gave the name of osteopetrosis, is a rare developmental error, the chief characteristic of which is excessive radiographic density of most or all the bones of the skeleton

**Familial and hereditary tendencies**—A distinct familial tendency is displayed and the disease is occasionally inherited, for example, eight cases occurred in three generations (McPeak 1936). It may be transmitted by either sex. Any special features which may be present are constant for a particular family. Consanguinity of parents has been noted, Nussey (1938) reported consanguinity in twenty-three of 112 cases.

**Sex**—The disease affects both sexes, males slightly more frequently than females.

**Age**—It has been found at all ages from foetal life to seventy-five years. It undoubtedly begins before birth in some cases, and possibly in most.

**Etiology**—The cause is unknown. Rather surprisingly, some have believed that parathyroid hyperactivity is responsible (Dupont 1930, Ellis 1934). A tumour of the parathyroid was present in one case but this was regarded, probably correctly, as secondary and defensive (Pehu *et al* 1931).

**Clinical features**—The chief features of the syndrome are abnormal density of the bones with or without fragility, a strong tendency to anaemia which may be severe and fatal, and optic atrophy. The severity and course of the condition vary considerably. It may run a benign or a malignant course, according to Nussey (1938) benign when the condition is inherited, and malignant when there is consanguinity of the parents. In a well-marked case, assuming that the patient survives, the formation of abnormally dense bone continues till growth ceases, the condition of the skeleton then remaining stationary, at any rate radiographically, though it may progress later. There may be intermissions, remissions, or complete cessation of the developmental error before growth ceases, all of which are demonstrated clearly in X-ray films.

**Tendency to fractures**—As a rule the bones are intensely hard like marble, but bones much softer and more like chalk were present in at least one case (Pirie 1930). A tendency to fracture is certainly present in some cases. One patient sustained ten fractures by the age of twenty years. On the whole fragility of the bones has been much exaggerated. When they occur fractures are sharp, abrupt, and transverse. Callus formation may be slow.

**Anaemia**—Usually there are no symptoms except those resulting from anaemia, which may become severe enough to call for investigation and may even be fatal at any age. It results from reduction of the blood-forming marrow in the sclerosed bones and eventually becomes of the aplastic type. Cases in which it was leukaemic and even apparently pernicious in type have been described. The anaemia is a source of real danger but it by no means corresponds always to the severity of the bone condition. A woman lived to the age of seventy-five years in spite of advanced petrosis of the whole skeleton and yet section of a femur in this case showed complete obliteration of the medullary cavity. Apart from the anaemia, blood examination reveals nothing of importance. The serum calcium is usually normal, but it is raised occasionally. When generalised calcinosis is present the serum calcium may even be doubled (Schulze 1921). The plasma phosphatase is either normal or slightly low. Children displaying

widespread abnormal deposits of calcium salts in the body may or may not have osteopetrosis in addition. If anaemia is severe, compensatory enlargement of the spleen, liver, and lymph glands may be present.

**Optic atrophy**—Optic atrophy may result from changes in the base of the skull but it is frequently absent. It has been seen as early as the sixth month of life. Nystagmus, hydrocephalus, facial, or ocular palsy, and deafness are other not very uncommon complications. The teeth are prone to decay. Some degree of dwarfism is often present. Osteomyelitis is stated to be not uncommon.

**Radiographic features**—As seen in radiographs, the extent to which bones are affected varies considerably. The whole of a bone including the epiphyses may be uniformly dense and completely structureless. With rays of sufficient hardness fine striations, both transverse and longitudinal, may be made out in the metaphyses and epiphyses (Sear 1927). Occasionally less dense areas may be seen in the sclerosed bone. The parts unaffected by petrosis may show osteoporosis but this is sometimes more apparent than real. As a rule metaphyses are more affected than shafts of the long bones, they are commonly enlarged or clubbed, the enlargement ending abruptly at its junction with the diaphysis. Occasionally the reverse holds good, the diaphyses being more affected, with the metaphyses less dense and either normal in shape or clubbed (Ellis 1934). A streaky or patchy arrangement of the denser bone is very rarely seen in cases of generalised osteopetrosis. Apart from clubbing, the shape of bones in both varieties is unaffected. In some cases a narrow clear transverse band marks the junction of diaphysis and enlarged metaphysis; in others, dense and less dense bands alternate. The unusual distribution of dense bone may suggest the markings of a zebra. The clavicles, the lower part of the humerus, and the radius and the ulna, may show less density than the rest of the skeleton. If, in a child, the tendency to form petrosed bone ceases suddenly after a time, the epiphyses will show a dense centre surrounded by a halo of bone of normal density. The ilia often show alternating dense and clear curved bands parallel to the crests. The carpal and tarsal bones, though sometimes universally dense or mottled, frequently show a dense centre surrounded by a halo of clearer bone, or the reverse may be seen when the pathological change began later than usual. Alternating concentric rings of dense and clear bone are not uncommon. As a rule the phalanges are decidedly less affected than the rest of the skeleton and they show a dense transverse band of varying width in the metaphysis, close to, or a short distance from, the epiphyseal lines. In milder cases these bands are a striking feature of the hands. Similar dark bands in the phalanges and at the ends of the long bones may, however, result from the absorption and deposition of lead, phosphorus, or bismuth. The skull shows the expected degree of density which is particularly marked at the base. The pituitary fossa is usually rather small, and the posterior clinoid processes are thick and clubbed, almost closing in the fossa. The air sinuses are invisible; the frontal and nasal bones may be thickened as well as dense. The maxillae may be affected but the mandible almost invariably escapes. Calcification of the dural folds may be seen. The vertebral bodies, if not uniformly dense, usually present two horizontal bands of dense bone above and below, with a less dense band between. The ribs are affected, sometimes irregularly, but the rib cartilages escape. In cases complicated by a tendency to generalised calcinosis, calcification may be seen even in children in the main arteries of the limbs, in the ligaments, the larger tendons, the kidneys, the walls of the trachea, the stomach, and in other soft tissues. Coxa vara, not the result of fracture, may be present; it was seen in three brothers all of whom showed generalised osteopetrosis. The deformity may be of the infantile or cervical type.

**Pathological features**—The petrosed bone is white-grey on section. The shaft of a long bone may be completely solid with the medullary cavity obliterated. The pathological changes are essentially sclerotic in nature, with increase in number and thickness of trabeculae. The architecture is disorderly and irregular. There may also be hypercalcification of

cartilage with persistence of nodules of calcified cartilage in the zone of newly formed trabeculae (McCune and Bradley 1934). The density may be increased further by deposition of calcium salts in the reduced medullary spaces when general calcinosis is also present. Spherical foci of ossification appear in the calcified cartilage. No fatty marrow is to be seen, what marrow there is being myeloid. Osteoblasts are either normal or increased in number, osteoclasts may be normal in number or absent. An important change found in the marrow is fibrosis. It has been suggested—and this seems quite possible—that in some cases the severity of the anaemia depends more on fibrosis of the marrow than on reduction of the marrow space by sclerosis. Reports on the chemistry are confusing, but it seems clear that the ossified bone matrix is normal in composition.

**Diagnosis**—The diagnosis is usually easy when radiographic examination has once been decided upon. In mild cases, chronic poisoning with lead or phosphorus must be excluded, while in certain localities, even in this country, fluorosis is worthy of consideration. Jupe (1938) reported in two cretins the finding of juxta-epiphyseal dense bands in the metaphyses which disappeared under treatment. Occasionally, limited distribution of the dense bone may give rise to difficulty in classification: such cases are probably best placed in the melorheostosis group.

The writer is greatly indebted to friends who have supplied him with clinical details of cases under their care and for permission to reproduce some figures from the *British Journal of Surgery*.

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#### CASE 14—OSTEOPETROSIS—Severe Type

(Figs 35–40) E L, girl aged 7 years. Genu valgum. Flat feet. Bilateral optic atrophy, left eye practically blind. Toes and fingers clubbed and oedematous. *Blood*—Red cells, 3,912,000. White cells, 5000. Haemoglobin, 47 per cent. Colour index, 53. Right femur fractured by fall and left femur fractured during application of tourniquet. (Under Mr McCrae Aitkin.)

FIG 35

Case 14. The shoulder, upper ribs and spine show involvement of all bones in the film. In the humerus there is involvement of the epiphyses; the metaphysis and shaft are enlarged (clubbed) and dense.

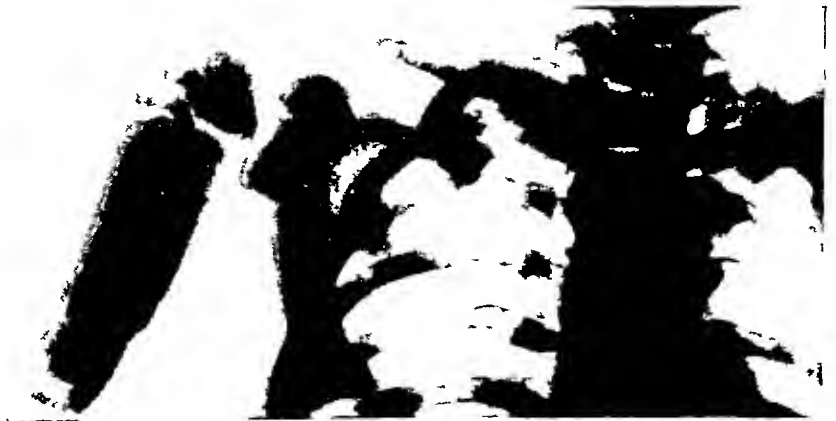




FIG 36



FIG 37



FIG 38

Case 14 The foot (Fig 36) shows every bone affected the intensity being most marked in the tarsus decreasing progressively towards the tips of the toes. Note that the metatarsals show general increased density which is greatest in the metaphyses whereas in the phalanges the petrositis is almost confined to the metaphyseal regions where the dense bone shows transverse striation. The hand (Fig 37) shows distribution of petrositis similar to that of the foot. The carpal bones show uniform density. In the region of the knee joint (Fig 38) there is very abrupt change from the less dense shafts of the femur and tibia to the more dense metaphyses. Note the obvious clubbing of these extremities with a suggestion of cross striation in the tibia and fibula and some longitudinal striation in the femur. The epiphyses are as dense as the metaphyses.



FIG 39



FIG 40

Case 14 The skull (Fig 39) is somewhat thickened and shows abnormal density especially of the base. There is no sign of the frontal sinuses. The pituitary fossa is rather small and the posterior clinoid processes are clubbed. There is some increased density of the maxillae but not of the mandible. The pelvis and upper femora (Fig 40) show marked clubbing of the femur on each side and complete lack of structure except the epiphyseal lines. The sacrum is less affected. In the iliac bones alternate dense and less dense bands are well seen. There is a curious vertical band of less dense bone in the upper part of the necks of both femora.



## CASE 15—OSTEOPETROSIS

(Figs 41-44) Half-caste Australian girl, aged two and a half years, who had never walked or talked. The parents and one sister were said to be normal. There was a slight squint and advanced optic atrophy. Anaemia and splenomegaly had been present for nearly two years. There was hypotonia of muscles and muscular wasting. The bones were easily palpable and the ends of the long bones were felt to be much enlarged. *Blood examination*—Red cells, 3,000,000. White cells, 10,000. Haemoglobin, 21 per cent. Wassermann negative. Blood calcium and phosphorus normal. (Under Dr Verco of Adelaide)



FIG 41

Case 15. The tibiae and fibulae show well-marked clubbing and clear bands with some longitudinal striation towards both extremities of the bones. The bones of the feet were not well seen but were obviously dense. The upper tibial epiphyses show a clear zone, surrounded by denser bone, and enclosing a dense central area.



FIG 42

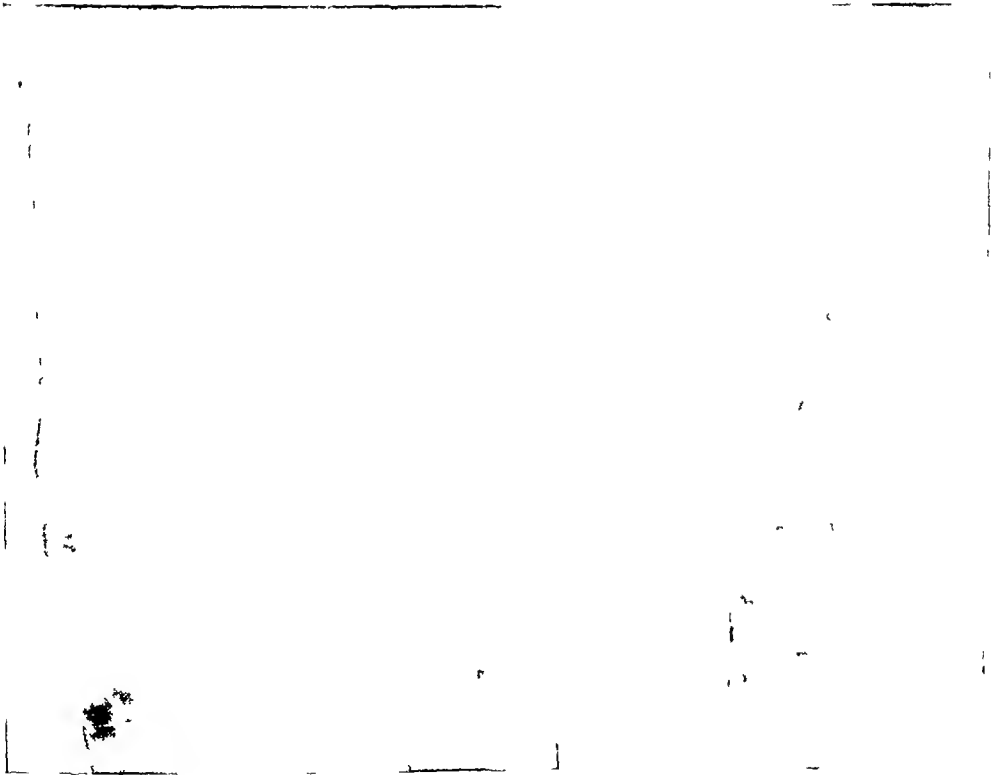


FIG 43



FIG 44

Case 15 The skull (Fig 42) shows increased density especially of the base and a small pituitary fossa with enlarged posterior clinoids. The lower jaw is strikingly normal in density but the maxillae are petrosed. The lower limbs (Fig 43) show increased density and loss of the normal architecture of all bones. Clubbing of the metaphyses is striking being most marked at the lower ends of the femora. Clear bands are seen corresponding roughly with the junction of shafts and metaphyses. The upper tibial epiphysis shows a clear ring encircling and surrounded by denser bone. Clear bands are also seen in the lower thirds of the forearm bones and metacarpals (Fig 44) accompanied by slight enlargement. There is a healed fracture of the left ulna. The phalanges as usual are less affected than the rest of the skeleton and they display no clubbing.

**CASE 16—OSTEOPETROSIS—Benign Type**

(Figs 45-49) H R, girl aged six years Condition inherited from the mother who is mildly affected (Case 17, Fig 50) There was no history of fractures The child was admitted to hospital for septic arthritis of the left hip joint Radiographic investigation showed clear evidence of a benign degree of osteopetrosis *Blood examination*—Red cells, 4,500,000 White cells, 11,800 Haemoglobin, 75 per cent Red cells normal Serum calcium rather high (12.8 mgms), phosphorus normal (5.6 mgms) No sign of optic neuritis (Under the late Sir Henry Gauvain)

**FIG 45**

Case 16 Pelvis and upper femora showing an unusual number of narrow alternating bands parallel to the iliac crests The femora are both affected in a somewhat patchy and unusual way, the appearance of the upper femoral shafts being rather suggestive of that seen in some cases of diffuse fibrosis of bone The changes in the region of the left hip joint are due to the infection of the hip joint with resulting decalcification causing less density of the left side of the pelvis and left femur than on the right side



FIG 46



FIG 47



FIG 48

Case 16 The knee joints (Fig 46) show alternate dark and light transverse bands with greatest density at the ends of the metaphyses suggesting that the tendency to formation of osteopetrotic bone is becoming more marked. The bands are broader and less sharply defined than the so-called lines of arrested growth. Dense bone in the epiphyses is distributed irregularly. The foot (Fig 47) shows unusual patchy distribution of dense bone in the metatarsals, typical bands in the phalanges which are parallel with but not adjacent to the epiphyseal lines and well-marked single or double rings in the tarsal bones. In the hand (Fig 48) there are dense bands and irregular areas of density in most bones. Note that the cortical bone seems less affected than the endosteal bone. All four inner metacarpals show a dense band at their bases while only two show density towards the distal or growing ends. Dense bands in the phalanges are some distance from the epiphyseal lines and not in the most recently formed bone as in Fig 46. The larger carpal bones show single dark circles



FIG 49

Case 16 The spine shows clearly the three bands in the vertebral bodies—a lighter band between two dark bands. The ribs show some increased density but they are not strikingly affected.

**CASE 17—OSTEOPI TROSIS—Mildest Type**

(Fig 50) Mrs R, mother of patient, Case 16 In perfect health Dense bone was seen only at or near the ends of long bones The outer condyle of the one femur that was X-rayed, and the outer tuberosity of the corresponding tibia, were more dense than the inner



FIG 50

Case 17 Hand showing similar distribution of dense bone to that seen in her daughter (Fig 48) The somewhat erratic distribution in the distal parts of the two outermost metacarpals is strikingly similar in the two cases

## CASE 18—OSTEOPETROSIS

(Figs 51-56) K L, woman aged seventy-three years The bone condition was discovered by accident after admission for a fracture of the femur Spleen not enlarged No anaemia No optic atrophy Blood examination negative Right femur had been fractured twice and left femur once Died at age seventy-five years (Under Dr W J Gill)



FIG 51

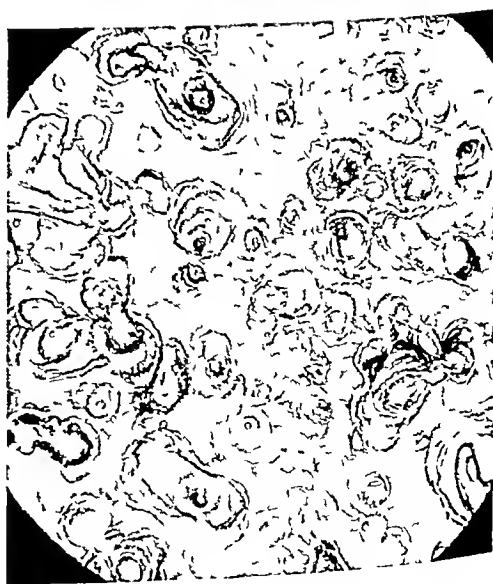


FIG 52

FIG 53

Case 18 The hands (Fig 51) show well-marked petrosis of all long bones. Note the alternating bands in the proximal phalanges. The lower epiphyses of radius and ulna and the carpal bones are partly involved. Cross section of the shaft of the femur (Fig 52) shows complete obliteration of the medullary cavity (the dark patch is an artefact). Microscopic section of the femur (Fig 53) shows the curious architecture of the dense bone. (By courtesy of Professor W G Barnard)

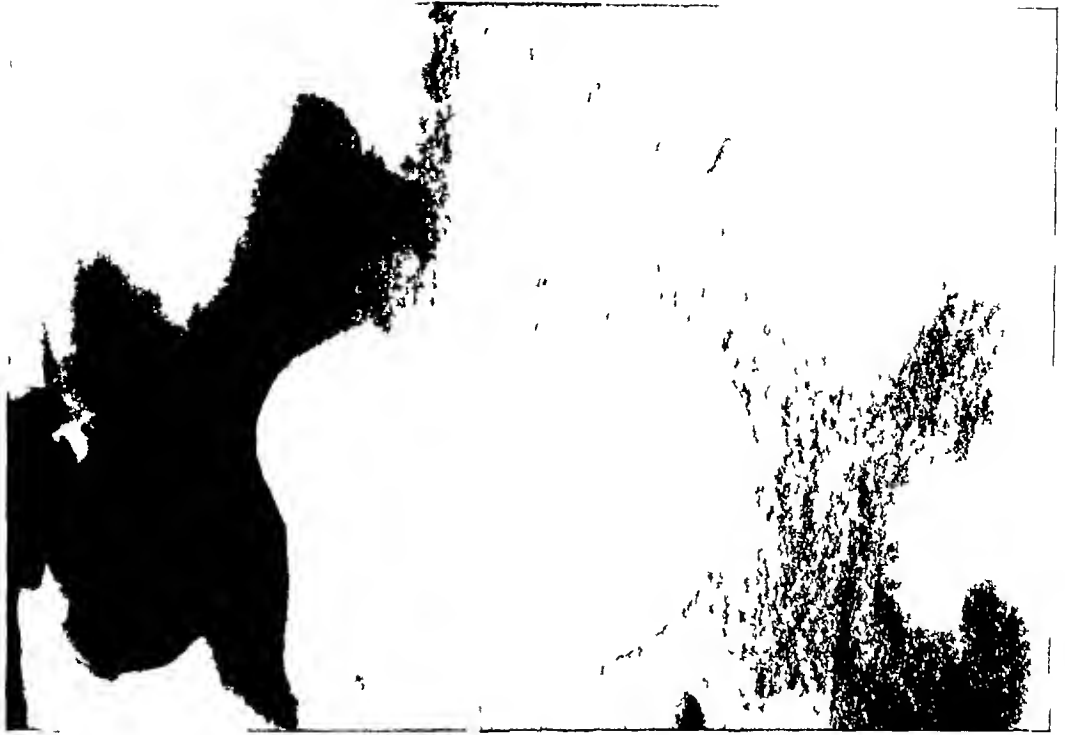


FIG 54



FIG 55



FIG 56

Case 18 The pelvis (Fig 54) shows generally increased density to a marked degree there are no definite curved bands in the ilia Old fracture neck of right femur The skull (Fig 55) shows increased density particularly at the base The pituitary fossa is slightly small The frontal sinuses are not visible The density of the facial bones and lower jaw is apparently normal The cervical vertebrae are dense The lower limb (Fig 56) shows almost complete obliteration of structure of all bones including the patella There is arthritic lipping of the knee joint



**CASE 19—OSTEOPETROSIS**

(Figs 57-61) C R, boy aged nineteen months Admitted to hospital because of general backwardness and failure to gain weight Right facial palsy No history of fractures *Blood examination*—serum calcium 13.5 mg per cent Blood cholesterol, 162 mg Haemoglobin, 84 per cent Wassermann and Kahn reactions negative (Under Professor Alan Moncrieff)

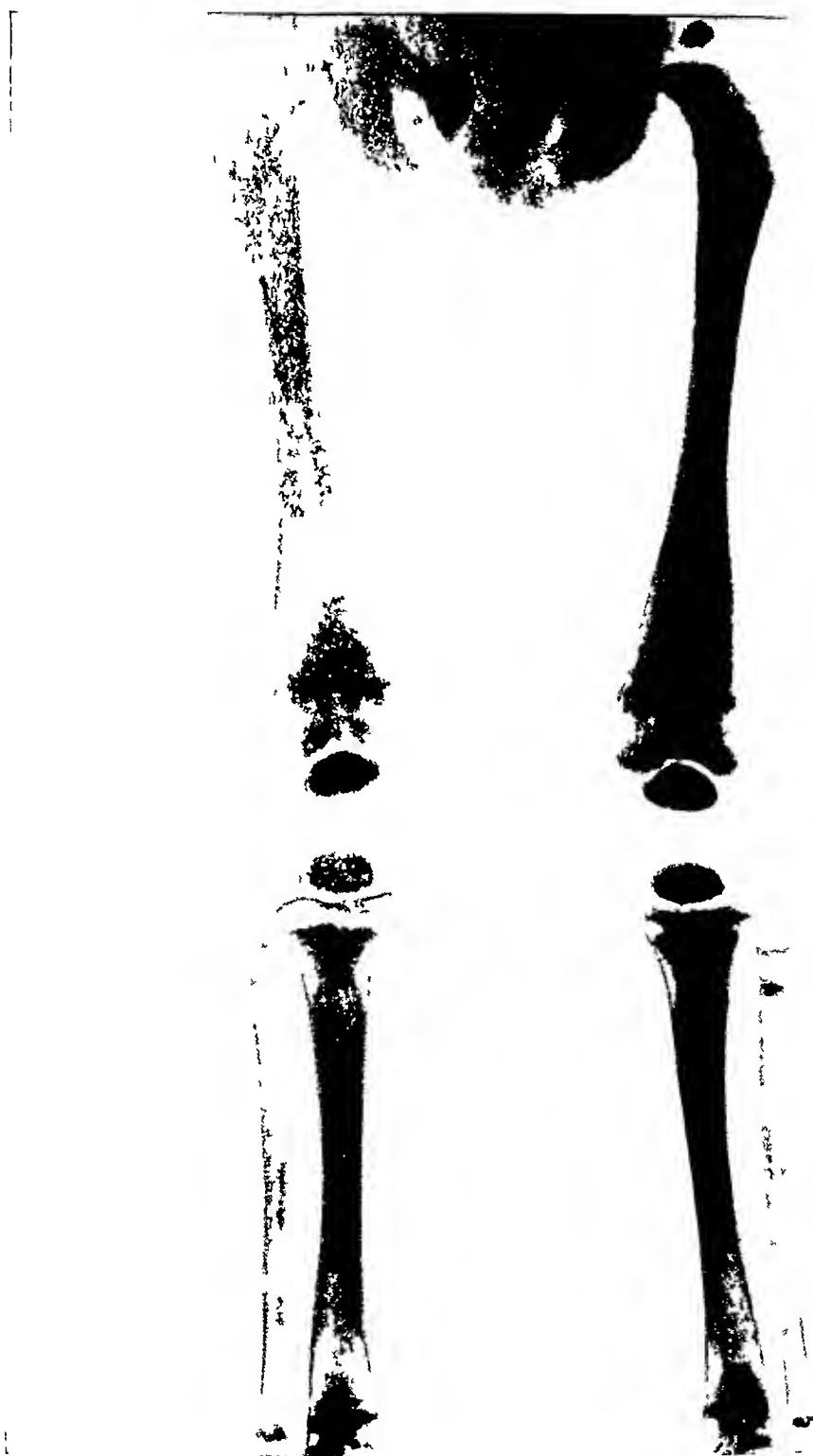


FIG 57

Case 19 November 1945 The lower limbs show general increased density of long bones ending abruptly above and below in intensely opaque bands a short distance from the epiphyseal lines Recently formed bone in the metaphyses is distinctly less dense than in the rest of the shafts

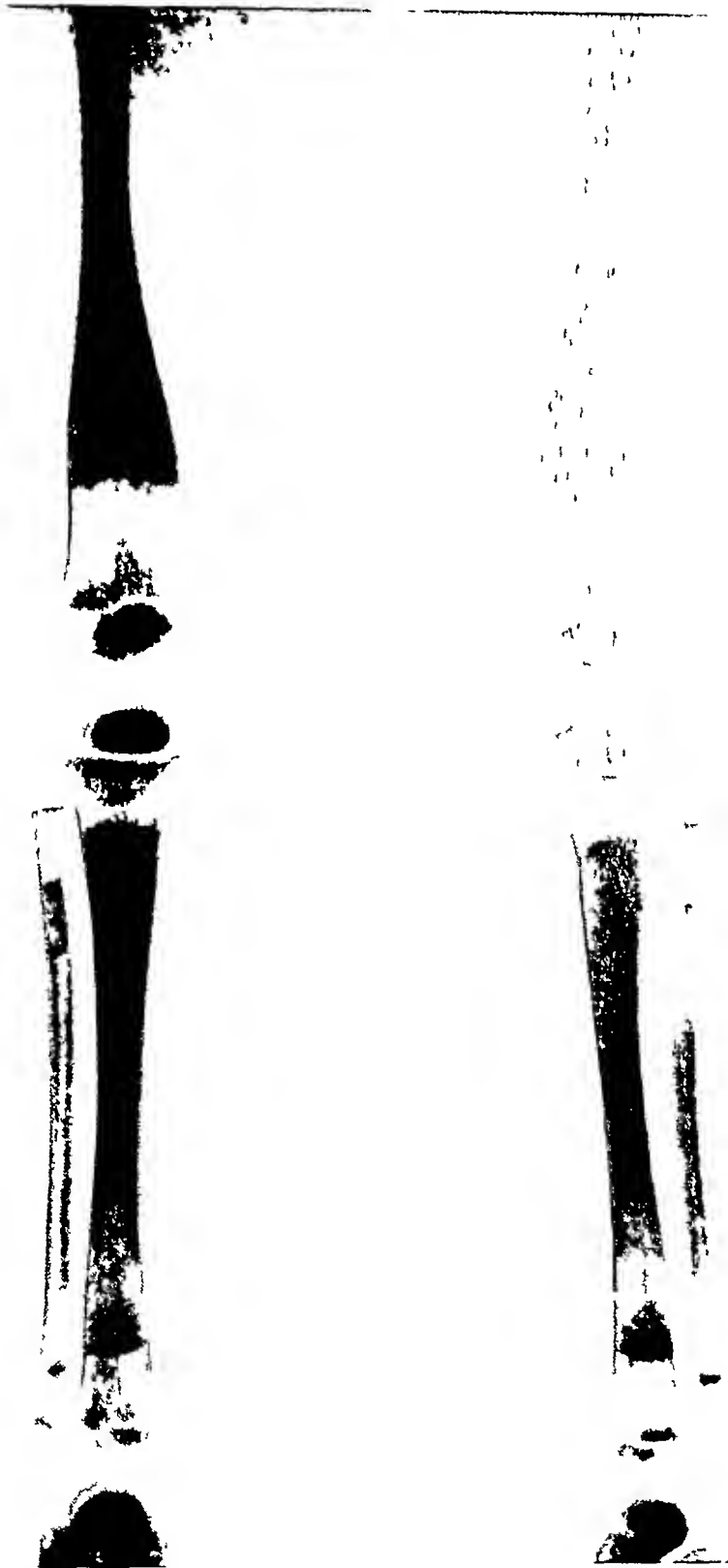


FIG 58

Case 19 July 1946 Film taken for comparison with Fig 57 Note that bone added during the interval of eight months has been unaffected by petrosis—in fact it is somewhat porotic New bone formed round the abnormally dense epiphyseal nuclei is of normal density The same is true of the tarsal bones



FIG 59



FIG 60



FIG 61

Case 19 July 1946 Radiographs of the upper limbs (Fig 60) show similar distribution and extent of density as in the lower limbs. The skull (Fig 59) shows increased density, notably of the base with thickening in the frontal region. The pituitary fossa is small. The maxillae are affected. There is increased density of vertebrae, sacrum ribs and sternum (Fig 61).

## CASE 20- OSTEOPE TROSIS

(Figs 62-65) R. P., boy aged five years. Admitted to hospital for pain in the region of the left hip joint of some months' duration. No optic neuritis. *Blood examination*—Red cells, 4,360,000. Hemoglobin, 90 per cent. White cells, 2,600 (Nine days later 6000) Neutrophils, 40 per cent. Lymphocytes, 56 per cent. Chemical analysis showed no abnormality. The evidence suggested an atypical case of osteopetrosis. (Under Mr D. B. Craig.)



FIG 62

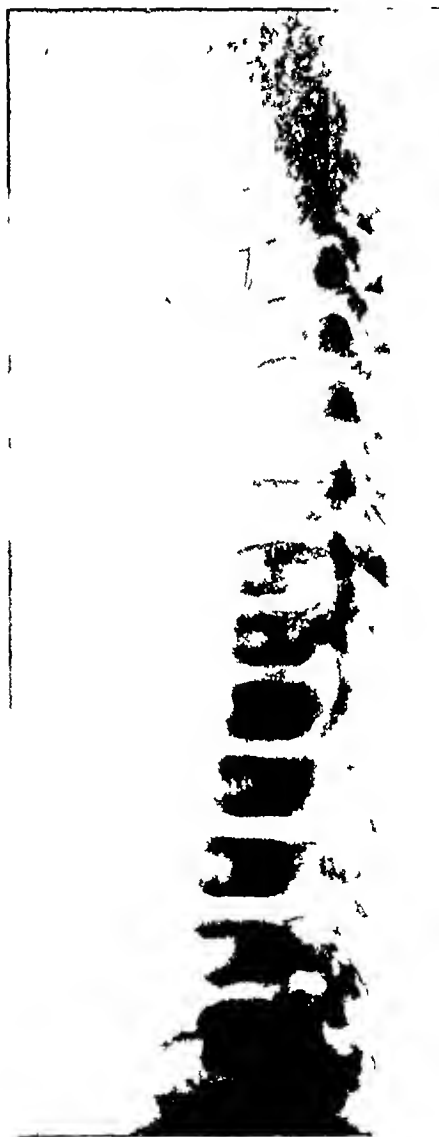


FIG 63

Case 20. The shafts of the femora (Fig 62) show unusual distribution of increased density particularly in the region of the knee joints. There is marked longitudinal striation of the metaphyses. Note what appears to be a chip fracture of the neck of the left femur with minimal displacement of the head suggestive of the infantile type of coxa vara. The spine (Fig 63) shows abnormal density of the upper and lower parts of each body with a less dense band between which is strong evidence in favour of the diagnosis of osteopetrosis.



FIG 64



FIG 65

Case 20 The skull (Fig 64) shows abnormal density particularly of the base. The pituitary fossa is small. The upper and possibly the lower jaw seem to be affected. The pelvis and hips (Fig 65) show fairly generalised osteopetrosis. There are faint bands parallel with the crests. The fracture of the neck of the femur suggestive of infantile coxa vara is again shown in this film.

## John Hunter

John Hunter was born on February 13 1728, at Long Calderwood, a small estate in Lanarkshire about seven miles from Glasgow. His father, whose name was also John, was one of the Hunters of Hunterston in Ayrshire—an old Scottish family. He and his wife Agnes had ten children of whom William was the seventh, and John the youngest. Both brothers achieved fame as anatomists but they were very dissimilar in temperament and character.

William was diligent as a boy, and at the age of fourteen went with a bursary to Glasgow University where he studied for five years. Afterwards he spent a short time in Edinburgh, and finished his medical training at St George's Hospital, London. Later he started a school of anatomy in Covent Garden which soon acquired considerable reputation by reason of the facilities he offered for dissection, and his own capacity as a lecturer. In 1770 he transferred the school to Great Windmill Street where a building had been erected with lecture theatre, dissecting rooms, and museum. He had already been elected physician-accoucheur to the Middlesex Hospital and later was appointed Physician Extraordinary to Queen Charlotte, but his main interest was anatomy, and he lectured upon it to the end of his life. He was elected a Fellow of the Royal Society to whose transactions he contributed a paper "On the Structure and Diseases of Articulating Cartilages." In this communication he was the first to give a clear account of the structure and arrangement of synovial membranes.

John Hunter was ten years younger than William Hunter. In early life he had none of the studious habits of his elder brothers, both of whom went to a university, one studying medicine and the other law. Being the youngest, and favoured by his mother, John was somewhat undisciplined. He was averse to schooling of any kind but gave early evidence of the thread of his peculiar genius when he rambled in the woods, watched ants, bees, birds, and tadpoles, and pestered country folk with simple questions on natural history. Until the age of twenty his mind remained fallow and untroubled, but on the verge of manhood he woke from slumber and for the next forty-five years worked so prodigiously in the production and study of scientific material in medicine and biology that the like of him has not been seen again. He began by joining his brother in the school of anatomy where he arrived exactly 200 years ago. He soon acquired such patience and skill as a dissector, and such knowledge of anatomy, that within twelve months he was appointed demonstrator. He studied surgery under Cheselden, and afterwards under Pott, the two master surgeons of the day. Later he enrolled as a pupil at St George's Hospital, and in due time became house surgeon. In 1759, through overwork in the dissecting rooms, he developed pneumonia, symptoms appeared which were suggestive of tuberculosis. He therefore sought a change of work and secured appointment as a staff-surgeon in the army. He sailed with the expedition to Belleisle, and in the war with Spain served on the frontier of Portugal. This gave him extensive experience of gun-shot wounds which was embodied in his "Treatise on the Blood, Inflammation, and Gun-shot Wounds."

He left the army after two years' service, took a house in Golden Square, and began his career as a surgeon. Having spent twelve years in the dissecting room, and carried out many researches, he brought to the practice of surgery a mind trained in scientific investigation. Private practice was subordinated to the study of comparative anatomy and biology which demanded all the time and money that he could devote. He acquired specimens from the menageries—dissecting the bodies of animals that died, and in order to study living animals both by experiment and by observation of their habits he bought, in 1764, two acres of land at Earl's Court which at that time was in the country, two miles beyond London. There he organised an experimental station and housed a great variety of wild and domestic animals.

from all over the world. He studied the structure of innumerable living organisms and observed the effects of disease and injury upon it. Dissected specimens were preserved carefully, and thus was built up an anatomical and pathological museum which became the bedrock of scientific study of surgery in England. He was elected a Fellow of the Royal Society in 1767 and was awarded its Copley Medal. In the next year he was elected surgeon to St George's Hospital and soon afterwards became a member of the Corporation of Surgeons. The pupils he attracted, who afterwards achieved great distinction, included Edward Jenner, Abernethy, Cline, Earle, and Astley Cooper. Unlike other teachers his lectures on surgery were based upon rational pathology, he insisted that the principles of surgery must first be understood before the cause of disease could be appreciated. But he had none of the eloquence of his brother, extempore expression of the thoughts which surged within him did not come easily. He read almost entirely from manuscript and even then his language was laboured. But it was what John Hunter had to say that was important rather than his manner of saying it. The casket was unadorned but the treasure within was of great value.

Soon after election to the staff of St George's Hospital he moved to a house in Jermyn Street, previously occupied by his brother, which was nearer to hospital, better situated for private consulting work, and offered greater accommodation for his increasing collection. A few years later he married Anne Home, a lady noted for her beauty, wit, and accomplishment—a social figure in the world of art. She wrote the words for Haydn's "Creation" and the stanzas for his English canzonets, the best known of which begins with the words "My mother bids me bind my hair." They lived in Jermyn Street for fourteen years until the ever growing museum overran the house and forced Hunter to seek still more spacious accommodation. In 1785 he moved to his last abode, a large house on the east side of Leicester Square. He bought another house close by and, on the land between, built a suite of rooms and a great museum. In his new quarters the dissection and collection of natural history specimens went on apace. At the same time his practice grew to such an extent that on the death of Percival Pott in 1788 Hunter succeeded him as the first surgeon in England. In his attention to patients he was thoughtful and self-sacrificing, he gave his services free to non-beneficed clergy and struggling artists.

Hunter took a conservative view of operations and always aimed at diminishing their severity, regarding many of them as an imperfection of the art of healing. He was deeply impressed by the natural resistance of the body to disease, and by its struggle against anything impairing the function of one of its parts. The sole business of the surgeon was that of a helper, claiming no more for his operation than lending his aid in that resistance and that struggle. It was appreciation of this inherent power of living tissues which led to his classical operation for popliteal aneurism. He was alarmed at the high mortality of prevailing treatment by amputation, or double ligature with evacuation of the blood sac. He had tied one of the external carotid arteries of a stag in order to observe the effect upon growth of the corresponding antler, to his surprise the horny outgrowth still kept growing. Wondering what had happened to his ligature he had the animal killed for inspection and to his amazement Hunter found that small branches of the artery above and below the occlusion had enlarged under "the stimulus of necessity," and by their anastomoses had restored blood supply to the growing part. He argued that if in the deer, collateral vessels could maintain circulation after ligation of the main artery, the same should happen in the human lower limb after occlusion of the femoral artery by single ligature. Acting upon this deduction, in 1785, he tied the femoral artery in the lower part of the thigh in a patient at St George's Hospital with a popliteal aneurism. Within six weeks the man left hospital with his life and his limb. The fibro-muscular sheath through which the femoral artery passes has ever since been known as Hunter's Canal. The evolution of this operation illustrates John Hunter's scientific approach and appeal to experimental methods in seeking the solution of surgical problems—an approach which in his day was strange, no matter how familiar it may be in ours.



John Hunter  
1728-1793

" For their work continueth, And their work continueth,  
Broad and deep continueth Greater than their knowing "

RUDYARD KIPLING





An investigation of great interest to orthopaedic surgeons was prompted by a personal injury. In 1767, while dancing, he ruptured his tendo Achillis. Thereupon he studied in animals the manner of reunion of divided tendons. He divided the same tendon in several dogs, by introducing a couching needle under the skin at some distance from it, and killed the dogs at different periods to see the progress of the union, which was found to be similar to that of fractured bones where the skin is not wounded. His museum included fine specimens of tenotomy from the ass and deer. The ends of the divided tendons had retracted but "the uniting medium was not distinguishable from the tendon itself except by being less glistening, by its fibres being less regularly parallel and longitudinal, and by its surfaces being united with the surrounding fibrous textures." Hunter observed that repair of the tendons proceeded just like that of simple fractures and without suppurative inflammation. This was an important statement of a principle. Upon it was founded the practice of subcutaneous surgery which until the coming of Lister was the only safe operative procedure for the cure of deformities.

He attempted the transplantation of tissues and successfully implanted a sound human tooth into a cock's comb. This striking experiment demonstrated his zeal and patience, for it was accomplished only after many failures. In the remarkable specimen preserved in his museum could be seen the injected blood-vessels of the comb penetrating the tooth. He thus proved that tissues of low metabolism could be grafted elsewhere if the blood supply was adequate—a principle upon which depended the successful bone grafting of later days. Bone growth aroused his interest. After much experimental work on pigs he laid it down that long bones are lengthened from the ends near the epiphyses, and not by interposition of new bone in the interstices of the old. Furthermore he showed that a bone became thicker by the deposition of new matter subperiosteally, and that bone is constantly undergoing change with simultaneous absorption and deposition of osseous tissue—an observation confirmed later by the microscope.

Study of the structure and function of the human body was only part of Hunter's work. His labours covered the whole field of natural history. In what does life consist was a question often in his mind. He regarded it as a principle tenaciously held and independent of structure. He sought to unfold the various phases of life. In his quest he dissected over 500 different species of animals and numerous varieties of plants. His search ranged from the sperm whale, with its aorta a foot in diameter into which passed at each heart-beat twelve gallons of blood, to the life of the bee which he watched for twenty years. His study of the structure and of the social habits of this honey-making insect was so extensive and protracted that it was only close to the end of his life that he collected his records together for publication in the Transactions of the Royal Society. If this had been his only contribution to knowledge his name would have been memorable.

Although later years were handicapped by ill-health he never slackened in the pace of his scientific work. His day started at six o'clock in the morning and ended well after midnight. For the last twenty years of his life he drank no wine. In 1785 he had his first attack of angina, and for eight years suffered periodical prostration, his life at times being held precariously in the balance. During this period he was well aware that emotional excitement might bring on a cardiac catastrophe. On October 16, 1793, he attended a Board Meeting at St George's Hospital. In a discussion about the admission of pupils to the hospital his feelings were roused. His old malady was stirred to activity. He rose from the table, hoping to control his symptoms, but had hardly reached another room when he fell groaning into the arms of a colleague and died. He was buried in the vaults of St Martin's-in-the-Fields. In 1859 Frank Buckland spent sixteen laborious days searching for John Hunter's remains. At last he found them. On March 28 the same year they were buried with great honour in Westminster Abbey.

John Hunter dedicated his life to scientific investigation and the building of a great museum. He gathered together thousands of his own dissections, even in his last years his

assistant tells how he often saw him "standing like a statue for hours over some delicate bit of dissection" Well has it been said that "he made his name immortal by the labour of his own hands outside the sphere of surgery" The care of the collection, which contained over 13,000 specimens, caused some anxiety to Hunter's family but in young Clift his assistant they found a faithful and devoted guardian For seven years he kept watch, preventing deterioration in the soft specimens, and making copious extracts from the manuscripts On June 13, 1799, the Government bought the collection for £15,000 and transferred it to the care of the Corporation of Surgeons A charter was granted to the Corporation on March 22, 1800, whereby they were constituted the Royal College of Surgeons in London and were empowered to examine candidates for the Membership The surgeons gave up Surgeons' Hall and moved to a house in Lincoln's Inn Fields In 1806 Parliament granted £15,000 to the College to build a museum and three years later another grant of £12,500 The surgeons themselves spent over £21,000 of their own money By a charter of 1843 the title of the College was changed to the Royal College of Surgeons of England and the Fellowship of the College was instituted

John Hunter has exercised a profound influence on British surgery This was achieved not by social gifts or personal attraction but entirely by his scientific mind When he started dissecting, three years only had passed since surgeons had ceased to be associated formally with the "art and mystery of barbers" But through his immense labours in comparative anatomy, physiology, and pathology, he raised the status of surgery to that of a scientific profession In his quest for truth by observation and experiment he displayed a penetrating vision extending far beyond the horizon of his own time His country experimental station long anticipated "Down House" which is now the experimental farm of the Royal College of Surgeons Most of his teaching is inevitably bound in the corpus of surgical doctrine and has lost its identity Like Lister he was interested in the phenomena of inflammation and coagulation of the blood but he was denied the use of a microscope and he little dreamt of a world of micro-organisms But his keen intellect noted and stressed mysterious variation in the reaction of tissues to injury according to whether the skin was broken or unbroken If the skin was intact the healing process proceeded smoothly, whereas with a broken skin suppuration was the rule and repair was disturbed and delayed And he pondered why His great museum is the proud heritage of the Royal College of Surgeons of England and it is fitting that on the anniversary of his birthday an oration in praise of him should be delivered by a distinguished disciple

ARTHUR ROCYN JONES

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# PIONEERS OF OSTEOGENY

JOHN HUNTER 1728-1793

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*From the Department of Human and Comparative Anatomy  
Royal College of Surgeons of England*

Hunter made observations on the growth of bone when he first began his lectures in 1772 but his experiments to show the method of growth were probably made long before this date. He was endeavouring to prove two hypotheses: 1) that growth takes place by the addition of new bone on the surface and 2) that the rate of growth is not uniform in all parts of the bone. Two different methods were used. Original specimens of each type of experiment are still preserved in the Museum of the Royal College of Surgeons of England and are here illustrated. In both methods Hunter had been anticipated by Henri Louis Duhamel du Monceau (1700-82).

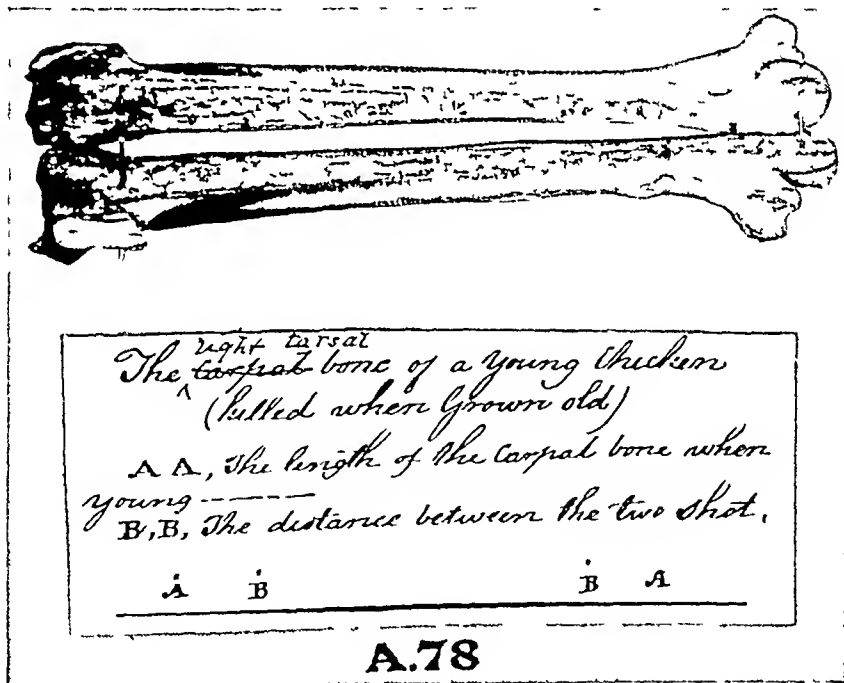


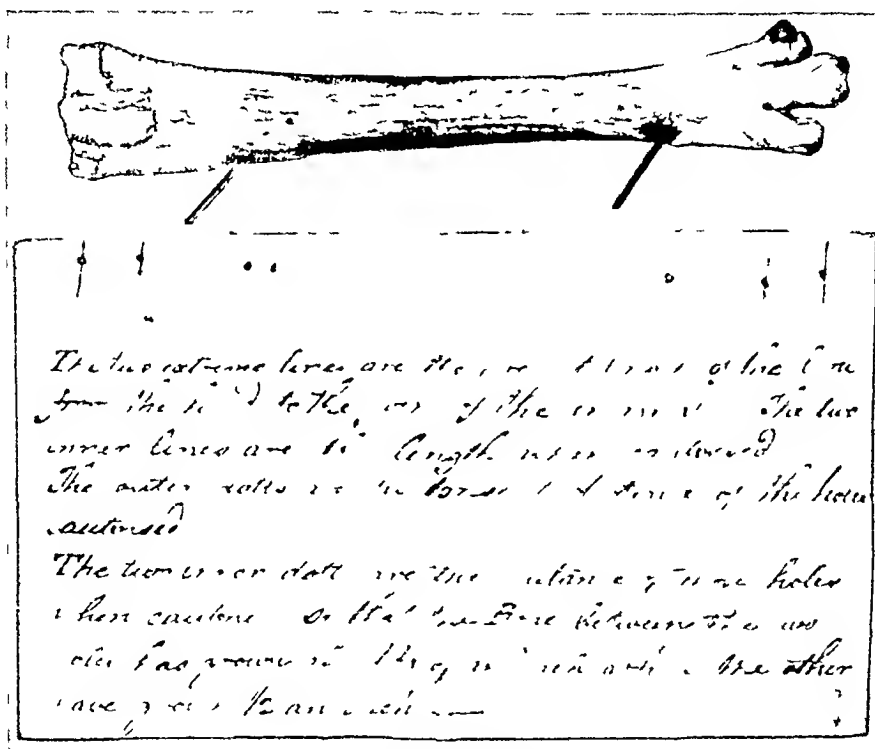
FIG 1

Photograph of one of John Hunter's specimens with the original note illustrating his experiments in the investigation of bone growth by the insertion of lead shot into drill-holes

Though Hunter left no consecutive description of his many experiments on bone growth, extracts from his writings give a clear indication of his methods and results. "Bones do not grow by having new particles put into the interstices of previously formed parts, so as to remove these to a greater distance from each other, by which means they should grow larger—as, for instance, if I put a sponge into water, the water getting into all the interstices makes

it larger—but they grow by the addition of new bone on the external surface. I took a pig of a very large breed when young, bored two holes in the tibia, and put a shot into each, measuring on a card the distance of each from the other. I allowed this pig to grow up to its full size, then killed it and took out the bone, and I found the two holes exactly the same distance from one another as at first. Now if the bone had grown in all its parts, these two shot would have been removed to a distance from each other proportionate to the growth of the bone."

A similar experiment was made on the right tarso-metatarsus of the domestic fowl and Fig 1 is a photograph of the actual specimen. It also shows the original note of the experiment which is preserved in the jar. Fig 2 is a photograph of another of Hunter's specimens in which he used a different method to demonstrate the same thesis—that bone does not grow at the same rate throughout. This preparation is the left tarso-metatarsus of the domestic



## A.79

FIG 2

Photograph of another Hunter specimen preserved in the Royal College of Surgeons of England in which he determined the method of bone growth by measuring the distance between points of cauterisation

fowl and here he was able to prove that increase of bone distal to the points of cauterisation is more than double that of the space included between them. Here again the original note on the experiment is preserved in the jar.

The second group of experiments consisted in feeding animals with madder, which has the property of staining more vividly with a red colour that part of the bone which is added while the animal is being fed with food mixed with madder. Hunter's best description of these experiments is to be found in that section of his work which deals with growth of the teeth. "Take, for example, any young animal, as a pig, and feed it with madder for three or four weeks, then kill the animal, and upon examination you will find the following

appearances first if this animal had some parts of its teeth formed before the feeding with madder those parts will be known by their remaining of the natural colour, but such parts of the teeth as were formed while the animal was taking the madder will be found to be of a red colour This shows that it is only those parts that were formed while the animal was taking the madder that are dyed, for what were already formed will not be found in the least tinged This is different in all other bones for we know that any part of a bone which is already formed is capable of being dyed with madder, though not so fast as the part that is forming therefore, as we know that all other bones when formed are vascular, and are thence susceptible of the dye, we may readily suppose that the teeth are not vascular, because they are not susceptible of it after once being formed But we shall carry this still further if you feed a pig with madder for some time, and then leave off for a considerable time before you kill the animal you will find the above appearances still subsisting, with this addition, that all the parts of the teeth which were formed after leaving off feeding with the madder will be white Here then in some teeth we shall have white, then red, and then white again, and so we shall have the red and the white colour alternately through the whole tooth This experiment shows that the tooth, once tinged does not lose its colour now as all other bones that have been tinged lose their colour in time, when the animal leaves off feeding with madder (though very slowly), and as that dye must be taken into the constitution by the absorbents, it would seem that the teeth are without absorbents as well as other vessels This shows that the growth of the teeth is very different from that of other bones Bones begin at a point, and shoot out at their surface, and the part that seems already formed is not in reality so, for it is forming every day by having new matter thrown into it, till the whole substance is complete and even then it is constantly changing its matter " Fig 3 illustrates these madder experiments and is a photograph of the lithograph made from the original drawing prepared for Hunter by his assistant, William Bell The original drawing is preserved in the library of the Royal College of Surgeons

Mention of "absorbents" in the above extract brings us to Hunter's original conclusions concerning bone and bone growth "Since we know that bones do not grow by fresh matter being put into all parts, so as to push the old matter to a greater distance but by new matter laid upon the external surface, let us see whether it is possible for bone to grow and retain its form without being taken down Let Fig 3, Plate XX, represent the head of the thigh bone of a foetus Now if the increase was accomplished by superimposed layers, one over the other, as in Fig 4, the head of the bone would necessarily become of an enormous size and in time would come down so as to occupy the middle of the bone while the cavity in the centre would not be enlarged Absorption, therefore, must necessarily go on to keep the bone of its proper shape Hence I call this the modelling process, for without this combined

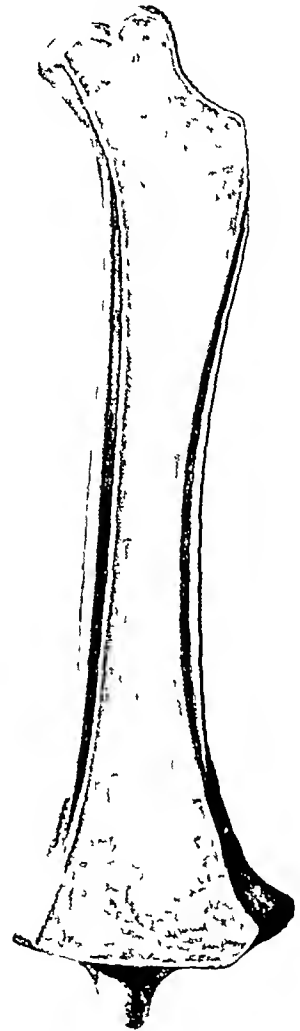


FIG 3

Photograph of William Bell's lithograph illustrating John Hunter's madder experiments

action of absorption and deposition the animal could not grow as it now does " The original figures to which Hunter alludes are reproduced in Fig 4

In addition to his experiments conducted to show the actual way in which increments were added to growing bone, Hunter (in Owen's "Essays and Observations") made this

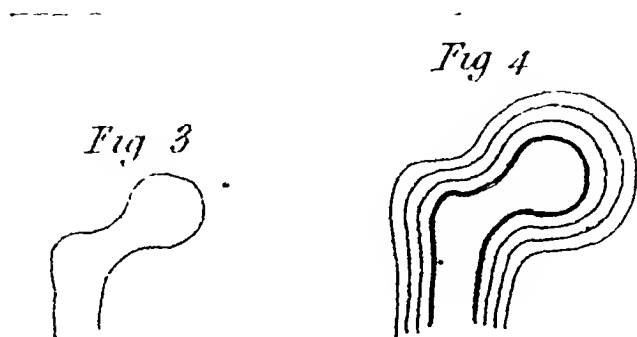


FIG 4

Plate XX of John Hunter's works illustrating the principle of the modelling process

shrewd, and doubtless original, observation on the tissue basis from which bone could be developed " Bone is not the original skeleton in any animal, but only of the adult, for in the first formation of any animal, which afterwards is to have bone, the skeleton is either membrane or cartilage, which is changed *for* bone, but not *into* bone "

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# ORTHOPAEDIC SURGERY IN THE SIXTEENTH AND SEVENTEENTH CENTURIES

## 1 Luxations of the Shoulder

WILLIAM BROCKBANK and D. L. GRIFFITHS, MANCHESTER, ENGLAND

*From the Medical Library of the University of Manchester*

Many books on surgery of the sixteenth and seventeenth centuries include important and well-illustrated sections on dislocations which is in rather striking contrast with the much smaller space allotted to fractures. These accounts, and the woodcuts that accompany them, are copied with slight modifications from book to book and from century to century. They give a clear account of the methods employed at that time. The illustrations reproduced are taken from books published in 1544, 1607, 1625, 1678, and 1693.

Perhaps the standard mediaeval treatise on the surgery of injury was that of Ambroise Pare (1510-1590) whose collected works were published in Paris in 1575. An English translation published in 1678 gives a good example of the text of such works and can speak for itself.

### " OF A DISLOCATED SHOULDER "

" The shoulder is easily dislocated, because the ligaments of its dearticulation are soft and loose, as also for that the cavity of the shoulder-blade is not very deep, and besides it is every where smooth and polite, no otherwise than that of the shoulder-bone, for that it is herein received. Add hereunto that there is no internal ligament from bone to bone, which may strengthen that dearticulation, as is in the leg and knee. Wherein notwithstanding, we must not think Nature defective but rather admire God's providence in this thing, for that this articulation serves not only for extension and bending, as that of the elbow, but besides, for a round or circular motion, as that which carries the arm round about, now up then down, according to each difference of site. The shoulder-bone may be dislocated four manner of ways, upwards, downwards, or into the arm-pit, forwards and outwards, but never backwards. Now Hippocrates saith that he hath only seen one kind of dislocation of this bone, to wit, that which is downwards to the arm-pit, and certainly it is the most usual and frequent, wherefore we intend to handle it in the first place. When the shoulder is dislocated downwards into the arm-pit a depressed cavity may be perceived in the upper part of the joint, the acromium of the blade shows more sharp and standing forth than ordinary, for that the head of the shoulder bone is slipt down and hid under the arm-pit, causing a swelling forth in that place, the elbow also casts itself (as it were) outwards and stands further off from the ribs, and though you force it, yet can you not make it to touch them, the patient cannot lift up his hand to his ear on that side, neither to his mouth nor shoulder. Also this arm is longer than the other. Lastly, the patient can move his arm by no kind of motion without sense of pain by reason of the extended and pressed muscles, some also of their fibres being broken "

### " Of the first manner of setting a shoulder which is with one's fist "

" First let one of sufficient strength, placed on the opposite side, firmly hold the patient upon the joint of the shoulder. then let another taking hold of his arm above the elbow so draw and extend it downward that the head thereof may be set just against its cavity hollowed in the blade bone. Then let the surgeon lift and force up with his fist the head of





FIG 1

Reduction of a dislocated shoulder by means of a towel around the operator's neck. It is presumed that reduction over the fist has failed. The resemblance of this method to methods still advocated for difficult hip-dislocations is striking. (From the English translation of Pare, 1678)



FIG 2

Reduction around the operator's heel (the classical "Hippocratic" method). From de Cruce 1607. Note again the use of the towel to provide lateral traction.

the bone into its cavity. But if the luxation be inveterate and the hand cannot serve then must the patient's shoulder be fastened to a post with a ligature or else committed to one's charge who may stand at his back and hold him fast. Then the arm shall presently be tied about a little above the elbow with a fillet whereto a cord shall be fastened, which being put or fastened to a pulley shall be drawn or stretched forth as much as need shall require. Lastly the surgeon with a towel or such-like ligature fastened about his neck and hanging down and so put under the patient's arm-pit near to the luxation, shall by raising himself upon his feet with the whole strength of his neck lift up the shoulder, also at the same time bringing his arm to the patient's breast shall set the head of the shoulder bone." (Fig 1)

**"Of the second manner of restoring a shoulder, that is with the heel when the patient by reason of pain can neither sit nor stand"**

"The patient must be laid with his back on the ground upon a coverlid or mat and a clew of yarn or leathern ball stuffed with tow or cotton of such bigness as may serve to fill up the cavity, must be put under his arm-pit, that so the bone may straightways the more easily be forced by the heel into its cavity. Then let the surgeon sit beside him even over against the luxated shoulder, and if his right shoulder be luxated, he shall put his right heel to the ball which filled up the arm-pit, but if the left, then the left heel. Then let him forthwith draw toward him the patient's arm, taking hold thereof with both his hands, and at the same instant of time strongly press the arm-pit with the heel. While this is in doing one shall stand at the patient's back, who shall lift up his shoulder with a towel and also with his heel press down the top of the shoulder blade, another also shall sit on the other side of the patient who, holding him, shall hinder him from stirring, this way or that way, at the necessary extension in setting it." (Fig 2)

**"The third method of restoring a shoulder"**

"Someone who is of competent height and strength shall put the sharp part of the top of his shoulder under the patient's arm-pit and also at the same time shall somewhat violently draw his arm towards his own breast so that the patient's whole body may as it were, hang thereby. In the meantime another, for the greater impression, shall lay his weight on the luxated shoulder shaking it with his whole body. Thus the shoulder, drawn downwards by the one which stands under the armhole, and moved and shaken by the other who hangs upon it, may be restored into its seat." (Fig 3)

**"Of the fourth method of restoring a dislocated shoulder"**

"You must take a perch or piece of wood (somewhat resembling that which the water-bearers of Paris use to put on their shoulders), some two inches broad and some six foot long. In the midst thereof let there be fastened a clew of yarn or ball of sufficient bigness to fill up the cavity of the armhole. Let there be two pins put in it, one on each side of the ball, each at like distance therefrom with which as with stays, the shoulder may be kept in, and upon the ball that it slip not away from it. Let two strong men taller than the patient by nature or art put this perch upon their shoulders. Then let the patient put his arm-pit upon that place where the ball stands up. The surgeon must be ready to pull his hanging arm downwards. Thus the patient as it were hangs on the perch with his shoulder and so the head of the bone shall be forced into the cavity." (Fig 4)



FIG 3

Reduction over the operator s shoulder The use of a child as an additional traction-  
force is not classical The illustration (from the Venice edition of Galen 1625) does  
not show the shoulder being shaken with the assistant s whole body as in  
Pare s text

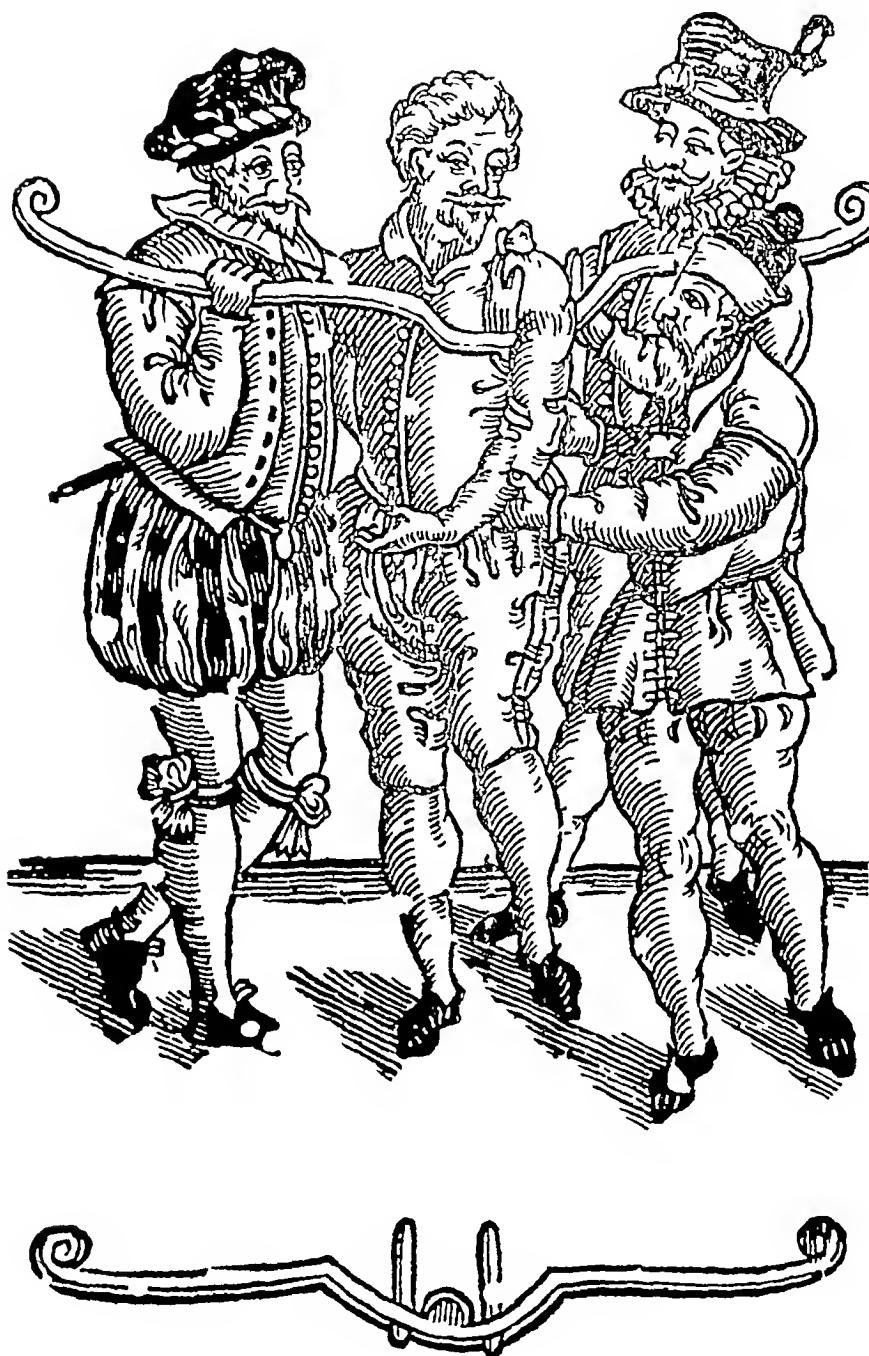


FIG 4

Reduction over a wooden voke. The author's insistence on adequate padding of the wood perhaps helped to reduce the chances of damage to the neuro-vascular bundle (From Paré 1678 *loc cit*)

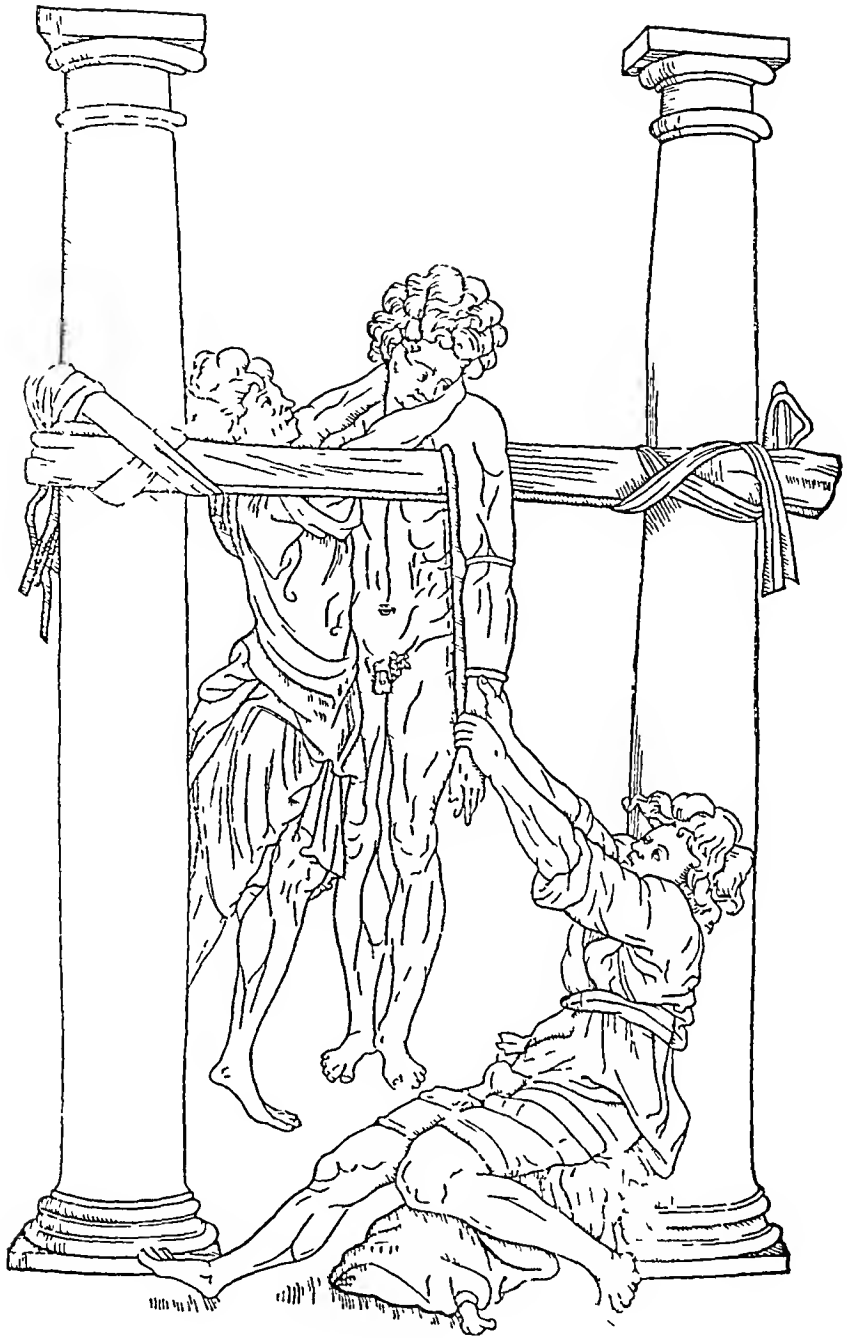


FIG 7

' The Very Best Way of Restoring a Shoulder , reduction over a beam  
A door could be used Note the wooden splint under the medial side  
of the arm (From *Vidius loc cit* ) This was reputed to be the favourite  
method of Hippocrates

steps Then his arm, bound above the elbow with filletting or some other ligature fit for the purpose, shall be drawn down by the hand of some that assist you, and at the same time let the stool be plucked from under his feet so that he may hang upon the ladder Thus by this means the head of the shoulder will be restored by itself, the endeavour of the surgeon assisting and pressing down on the shoulder blade, and moving it to and again The bone being set, the stool which a little before was plucked from under the patient's feet shall be put there again that he may with the more ease and less pain, pull back his arm from the step of the ladder, for if he should lift it high up to draw it over, there would be danger lest being newly set, and not well staid, the head of the bone might fall out again I have

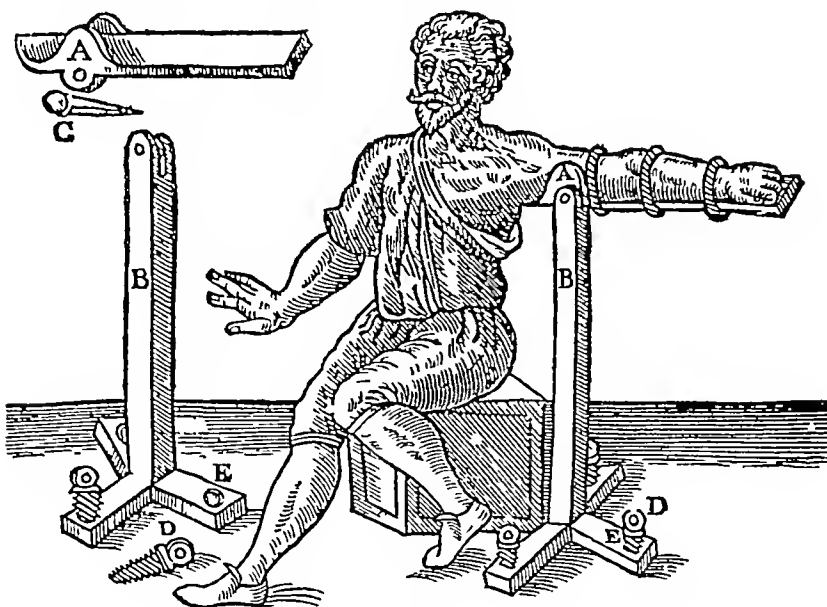


FIG 8

An alternative method (Pare—*loc cit*) The use of a hinge and of a shaped splint is fully explained by the illustration



FIG 9

Reduction of the dislocation by a mediaeval type of screw traction This picture from Scultetus (1693) is not much later than Pare and represents a technique which does not appear to have been known to the Greeks Scultetus (Johann Schultes 1595-1645) was famed for his illustrations of surgical instruments and appliances

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ORIBASIVS



FIG 10

The use of the rack to reduce a shoulder dislocation (Vidius—*loc cit*)

thought good to have all these things here expressed, that you may learn this operation as if you see it done before you

"If you have never a ladder you may use a piece of wood laid across two posts. Also you may use a door as the other figure shows wherein you must observe a flat piece of wood with strings thereat" (Figs 5-6)

#### "Of the sixth manner of restoring a shoulder luxated into the arm-pit"

"Hippocrates writes that this is the best way to reduce a dislocated shoulder. You must take a wooden spatula some four or five fingers' breadth and some two fingers' thickness or less and some yards long. The upper part must be wrapped about with a linen or woollen rag that it may be the softer and hurt the less and then it must be so thrust under the arm-pit that it may thoroughly penetrate into the inner part between the ribs and the head of the shoulder bone, and bound by the strings to the arm. Next you must make use of a ladder, door, bedposts, or such like thing as shall be present at such a height that the patient may stand on tip-toes. Now this is the very best way of restoring a shoulder" (Fig 7). Fig 8 illustrates an alternative and rather more complicated method mentioned by Pare.

The last two pictures accompanying this paper are not concerned with Pare's text. Fig 9 which appears in Scultetus (*Armamentarium Chirurgicum*, 1693) is reproduced largely to demonstrate that screw-traction is much older than its present-day users, and Fig 10 (from Vidius—*Chirurgia*, 1544) shows the rack, the classical mediaeval instrument of torture, being used as a means of reduction of a difficult shoulder dislocation, the usual role of the appliance being in this case reversed.

Very little need be said about these pictures but it is interesting to note that backward dislocation was not recognised in 1600. It is also of interest to observe that although some little advance has been made since the days of Hippocrates, yet most of the manoeuvres described are frankly plagiarised from the Greek. The text which is quoted is, in places, almost a translation of parts of the writing of Hippocrates (Worthington 1927).

Reduction of the shoulder around the operator's heel (Fig 2) has long been styled the "Hippocratic method". It seems, however, that reduction over the operator's shoulder was actually the favourite method in the Greek gymnasia (Fig 3). The addition of the weight of a child to the traction force is not seen in the one Greek illustration of the method which is available.

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## SIR WILLIAM MACEWEN (1848-1924)

### An Eponymic Centennial Note

A century has gone full circle since Sir William Macewen was born on June 22, 1848, and yet his huge personality continues to overpower our generation. In the history of bone and joint surgery his name will forever be eponymously honoured through his operation which marks but one aspect of his life-long interest in bone problems. His classic monograph, "Osteotomy with an Inquiry into the Aetiology and Pathology of Knock-Knee, Bow-Leg, and other Osseous Deformities of the Lower Limbs," published in 1880 at the early age of thirty-two, is a succinct, lucid, comprehensive presentation of the subject, with the accent of finality on every page. Translated into many languages, it spread his fame throughout the civilised world. This extract is characteristic of the style —



"On April 11th 1875 I performed antiseptic osteotomy on a girl, six years of age who had osseous ankylosis of the right knee, following suppuration of the joint, rising as a sequela of scarlet fever. The limb was straightened, and the wound healed as a typically antiseptic wound does. This was the first case of osteotomy performed in Britain. The second was performed by Lister during the winter session 1875-76. Antiseptic osteotomy was performed for the first time in London by Mr Barwell (Richard Barwell, F R C S, Surgeon to Charing Cross Hospital) on December 2nd, 1876. During the last few years antiseptic osteotomy has been greatly extended and it has met with such success as to ensure it a permanent place as a safe, certain, and most successful procedure" (p 62)

The following extracts may be quoted from his "Clinical Lecture on Antiseptic Osteotomy Having Special Reference to the Kind of Instruments Used, and to the Surgical Anatomy of the Extra Articular Operation by Simple Incision at the Lower End of the Femur for Genu Valgum, delivered at the Glasgow Royal Infirmary" <sup>1</sup>

In this morning's remarks references will be made, among other points to the following: the age suitable for such operations; the kind of instruments employed, and how to use them; and the surgical anatomy of the site selected for my operation of simple femoral incision in genu valgum. The chisel ought to be made to suit the material upon which it is to act. It ought to be made of very fine steel, tempered so as to prevent brittleness or too great softness. To employ a single word which would at once distinguish it from the ordinary chisel and at the same time be more euphemistic to a patient's ear, it might be called an *osteotome*."

The first set of osteotomes was made in 1876 by T. H. MacDonald, a blacksmith of Glasgow, under Macewen's direct supervision. The instrument was forged in a single piece and highly polished, at a time when bone-handled scalpels and wooden-handled chisels were universally employed, for Macewen had clearly grasped the principles of aseptic surgery.

Sir William Macewen's was a magnificent figure, with chiselled features and piercing grey eyes. His voice was low and mellow and, even when lecturing, hardly raised. He had an intense dislike to be photographed. A difficult character, he was essentially an individualist, unwilling or unable to share his ideas with colleagues or juniors, and he failed to win the affection of those who were his most devoted disciples.

W R BETT

<sup>1</sup> British Medical Journal 1879 1, 656-658

SIR H A THOMAS FAIRBANK, D S O , M S , F R C S , M Ch Orth (Hon )

*" Haec studia adolescentiam acciunt, senectutem oblectant "*

Sir Thomas Fairbank may be the oldest member of the British Orthopaedic Association, but in mental vigour he is one of the youngest. Regarded with affectionate respect, he is sought by young and old for his encyclopaedic knowledge and sound clinical judgment which are based upon a vast store of remembered experience. He has an insatiable thirst for knowledge and in the words of Cicero " the studies which were an impetus to his youth do now in age provide his delight "

In Fairbank we see embodied much of the history of the British Orthopaedic Association. Orthopaedics in Great Britain arose from two main stems: from Liverpool through Hugh Owen Thomas and Robert Jones, and from London through Jackson Clarke, Tubby, Muirhead Little, and Openshaw, who were general surgeons. Of the next generation—Elmslie, Trethowen, Bankart, Fairbank and others—Fairbank was first to gain appointment as orthopaedic surgeon to a London teaching hospital, the Charing Cross Hospital in 1906. Similar appointments were soon established elsewhere, but for the first thirty years of this century London orthopaedics grew despite opposition and obstruction, and it was the sincerity and integrity of this modest man which counted for so much in gaining the co-operation of general surgical colleagues.

Through family influence, Fairbank intended originally to go in for dentistry. He qualified in medicine but also took the dental diploma. Indeed, if it had not been for the South African War, he might well have become established as a West End surgeon-dentist. But he served as medical officer with the troops in South Africa, and on his return was appointed Medical Superintendent at the Hospital for Sick Children, Great Ormond Street.

He saw the demonstration by Lorenz in January 1903 at the City Orthopaedic Hospital and three weeks later, being then a clinical assistant, he reduced his first congenital hip dislocation. Here also he came under the influence of Lane whose teaching of the " non-touch technique " he accepted and thereafter never ceased to teach and practise. It is said that in the twenty-eight years he worked at Great Ormond Street, and did much of his most important work, he was not communicative, but he taught by example, by the skilful handling of children, the careful management of orthopaedic appliances, and by the qualities of neatness and attention to detail. Sir Thomas has generally managed through gentle but firm persuasion to get his own way, and this was illustrated in his successful breaking of a long tradition of the London hospitals by which all out-patients were seen by assistant surgeons regardless of the fact that they had been treated in the ward by senior surgeons who never saw them again. Throughout the time that Fairbank served as senior surgeon, from 1913 to 1928, he shared with his assistant both in-patient beds and out-patient follow-up clinics. This practice, started at Great Ormond Street, is now almost universal throughout Great Britain.

Before the 1914-18 War, Fairbank toured North America and gained stimulus from Royal Whitman, Lovett, and Abbott, and from Goldthwait whom he had met years before in Liverpool with Robert Jones. He was a keen territorial soldier and, when war broke out, was soon in Flanders with the 85th Field Ambulance. It was only by the folly of military regulations that this mature surgeon continued to serve as junior medical officer while young men he had trained were given first-class surgical appointments. In due course, however, this was remedied. He became surgical consultant to the Army, taught bone surgery to men who were destined to become orthopaedic leaders of the future, helped to establish in the

Balkans a unit for the segregation and rehabilitation of injured men, served in the first Orthopaedic Centre at Shepherd's Bush, and took a prominent part in establishing the principles of treatment which are now generally acknowledged

On returning to Great Ormond Street he restricted his practice to orthopaedics, and shortly afterwards was invited to establish a new orthopaedic department at King's College Hospital. Thus started a new and fruitful phase, loyally supported by general surgical colleagues and assisted at King's by Dudley Buxton who, in 1922, helped him to establish the first fracture clinic in London for ambulatory cases. At that time he was joined by Sister Bradbury from Great Ormond Street, a devoted assistant who has done so much to maintain



Sir Thomas at his desk

his unique collection of radiographic and clinical material. In 1926, on the suggestion of Sir Henry Gauvain, he was appointed as first consulting orthopaedic surgeon to the Lord Mayor Treloar Hospital at Alton. This was the last hospital appointment he gave up, in 1946.

No record of the contribution of Sir Thomas Fairbank would be complete without comment upon his phenomenal work during the 1939-45 War. The Minister of Health invited him to act as chief orthopaedic adviser for the Emergency Medical Service. His responsibilities included expansion of existing orthopaedic facilities, development of facilities which did not exist, co-ordination of the work of regional advisers, negotiations with Service departments, and discrimination in the demand for trained orthopaedic surgeons between the needs of civilians on the home front and the expanding requirements of the armed forces. His labours were crowned with a degree of success which none other could have achieved, for he was held in such high respect, it was known that being armed with the powers of a dictator he seldom used them, and it was recognised that the force he preferred was that of

reason and persuasion. Those who know him at the periphery are still astounded by his memory of patients, and knowledge of the details of local hospital organisation.

It is in the clinic that Sir Thomas' discernment and knowledge is so striking. On one occasion at Great Ormond Street, on hearing the peculiar and piercing scream of an infant at the other end of the out-patient hall he remarked "That sounds like the cry of infantile scurvy." And so it was. He is a careful operator, always conscious of the patient, no trouble is too great and there is no excuse in his vocabulary. His teaching is intimate, helpful, and amusing.

Fairbank's contribution to orthopaedic literature is voluminous. He speaks often at medical meetings and always with something worth saying. The period of most prolific writing dated from his appointment to King's College Hospital after the first war, but already he had made important observations on the treatment of Erb's palsy, the correction of con-



The old Hospital for Sick Children Great Ormond Street

tracture of the subscapularis for which his operation was devised, and the treatment of congenital dislocation of the hip joint which he discussed with increasing knowledge and experience in later years. In 1922 he was able to report upon one hundred and seventy-five congenital dislocations treated between 1903 and 1914. The Lady Jones Lecture, published by Fairbank in 1930, included a fascinating discussion of the pathological anatomy of congenital hip dislocation, the mechanism of limp, the ligamentous and muscular slings which support the pelvis on the femur, the power of adduction of these muscles, and the part they play in the Trendelenburg gait. It can still be read with profit by all who deal with these dislocations.

A few weeks ago Fairbank put his views as follows — "Congenital hips are of three types 1) imperfect acetabulum, with the femoral head in the joint, but slightly eccentric, 2) subluxation, including 'marginal displacement', 3) dislocation on the dorsum ilii. The first is commonly overlooked until adult life when arthritis develops. It may be seen in the opposite hip, previously regarded as normal, after a unilateral dislocation has been dealt with. If spotted early enough operation to improve the acetabulum is well worth consideration. In the second type when the head rests exactly opposite the upper limit of the socket, the

prognosis is very bad unless an operation is performed to improve the roof of the acetabulum and make a lip. If the child is only two years of age or less, I think it is worth trying conservative measures, but if approaching the age of four I think it is essential, after manipulation to get the head central and the limb in a stable position, to follow this by the so-called upper lip operation.

"Open reduction *per se*, without an upper lip operation, has no advantage over closed reduction, since ultimate success always depends upon retaining the limb in the chosen stable position long enough to allow the acetabulum to acquire a shape that is approximately normal. I am not maintaining that open reduction is never advisable, for I think it occasionally is, for example when manipulation fails to achieve reduction, the child being sufficiently young. The hip should also be opened if after manipulation it is found to be exceptionally unstable, or the X-ray shows the head is not really home in the acetabulum.

"In the young, under three years of age, a subluxated and a luxated hip should be treated in the same way, namely by manipulative reduction (simple gradual abduction if under twelve months) and prolonged fixation. I believe that further manipulations in various directions, carried out after reduction and before applying the plaster, are of real value in getting the head really home and getting rid of possible folds of capsule nipped between the bones. I think it is a mistake to include the knee in plaster as a routine, because rotatory movement of the head in the acetabulum is useful, and one likes to get the hamstrings stretched. Ante-version I believe seldom calls for correction.

"My forty-five years experience of this problem leads me to emphasise the difficulty of what I would call the 'diagnosis of prognosis.' Recently reviewing some of my twenty-year results I have been struck by the very good results obtained in cases that at first had seemed imperfect, and vice versa. The one criterion I would stake everything on is the centering of the femoral head in the acetabulum."

In making a life-time study of the complexities and problems of general pathological lesions of the skeleton, Sir Thomas has done much to bring order out of chaos. His Presidential Address to the British Orthopaedic Association (British Journal of Surgery 1927) is a classic of modern orthopaedic literature, in which is classified and distinguished a great variety of developmental errors in bone formation, disturbances of bone structure, disorders of metabolism, and deviations of growth. He returned to the subject in the first Robert Jones Memorial Lecture (British Journal of Surgery 1939), discussing skeletal lesions with increased and decreased density of bone, and emphasising the part played by fibrosis of the marrow. More recently, under the title of "Dysplasia Epiphysealis Multiplex," he presented to the Royal Society of Medicine a critical analysis of disturbances of epiphyseal growth, isolating a group of cases with mottled bone formation differing from the changes of Perthes' disease, dyschondroplasia, dysplasia epiphysealis punctata, Morquio-Brailsford anomaly, etc.

Sir Thomas is a collector of the rarities of bone pathology. But he is more than a collector, by endless thought he is handing back his records, and those referred to him by many friends and colleagues, to the common pool of well-ordered classification. With an unrivalled experience of congenital dislocation of the hip joint his great delight is to discuss new ideas with junior members of the profession who have studied individual cases in detail. Of congenital talipes equino-varus he believes that "failure to get good results is due entirely to the failure of surgeons to take infinite pains with every case, this ultimately is the secret of the Denis Browne method, which in other respects is a good method." One of his greatest recent pleasures was to see the precision, attention to detail, and timeless consideration with which Smith-Petersen performed an arthroplasty of the hip joint in London. Of the "clever surgeon" who is technically dexterous, Fairbank comments "Of far greater importance is the man's intellectual integrity."

"Great men are the guide-posts and landmarks in the State" said Edmund Burke. Of such is Thomas Fairbank.

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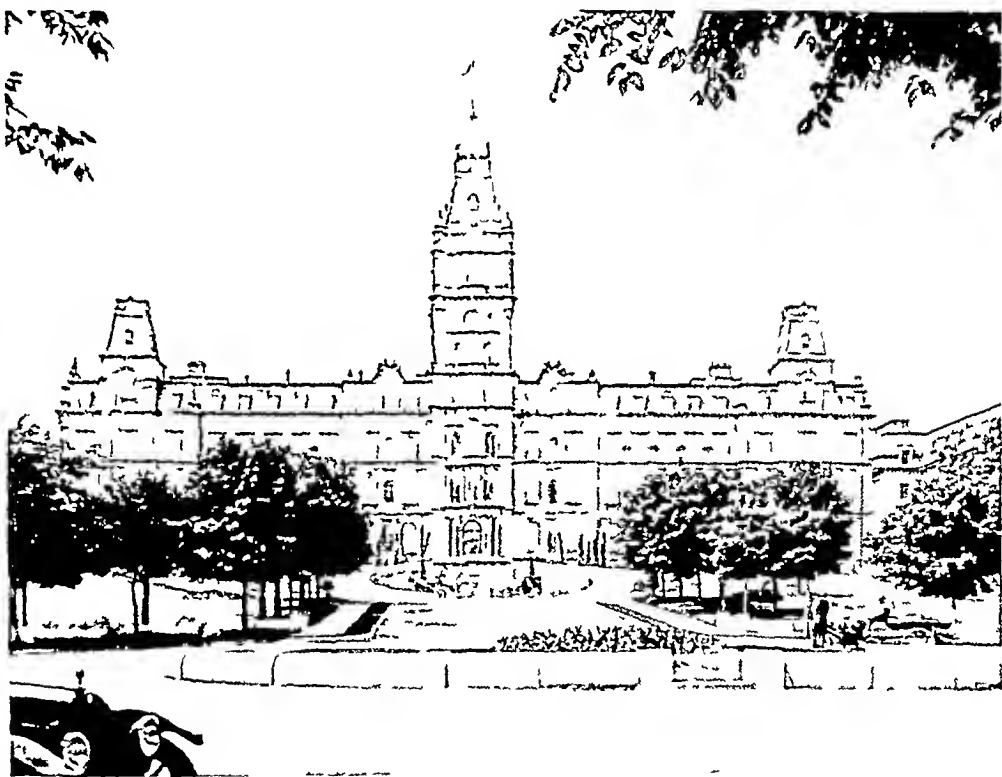
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# PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

## CANADA

### JOINT MEETING OF THE CANADIAN, BRITISH AND AMERICAN ORTHOPAEDIC ASSOCIATIONS

Canada is to serve as host for the combined meeting of the American British and Canadian Orthopaedic Associations which will be held in Quebec City in June. The American Orthopaedic Association will be led by their president Dr Robert I Harris of Toronto. Dr J Edouard Samson of Montreal will preside over the meetings of the Canadian Orthopaedic Association. The British Orthopaedic Association will be represented by the president Mr Alan S Malkin of Nottingham \* and a small group of surgeons.



The Joint Meeting of Canadian British and American Orthopaedic Associations will be held in June 1948 in Quebec the oldest city in Canada, and the centre of Government of French Canada. This photograph reproduced by courtesy of Canada House London shows the Provincial Parliament Buildings of the City.

who will endeavour to make good their lack of numerical strength by the vigour of their youth. The programme has been arranged by a committee under the capable chairmanship of Dr John L McDonald of Toronto whose organising ability was once demonstrated in Chicago when he saved the life of the British Editor of this Journal by disguising him as ' Mr Smith '. Clinical presentations, symposia, short

\* The Editor would take this opportunity of regretting that in the first British number of the Journal the name of Mr Alan S Malkin, who was then president-elect of the British Orthopaedic Association was not included in the list of representatives of the British and American Orthopaedic Associations who joined in the London Conference on future developments of the Journal of Bone and Joint Surgery. Having regard to the important part he played the omission was all the more unfortunate but we know that our respected president will forgive the oversight.



- papers executive sessions and banquets, will occupy every moment from early Thursday morning June 3 until late Sunday evening June 6. The provisional programme includes these papers and discussion:
- Aseptic Necrosis of Bone and Fractures of the Neck of the Femur**—Edward Compere, Chicago W W Plummer, Buffalo Dallas Phemister, Chicago, James Patrick, Glasgow Jackson Burrows London W Edward Gallie Toronto
- Subtrochanteric Leg Shortening**—Lawson Thornton Atlanta, Discussion—Walter P Blount, Milwaukee
- Ischio-femoral Arthrodesis of the Hip Joint**—Herbert A Brittain, Norwich Joseph Freiberg Cincinnati
- Osteoid Osteoma**—Malcolm Dockerty Rochester Discussion by Ralph Ghormley, Rochester, Campbell Thomson, New York
- Slipping of the Upper Femoral Epiphysis**—Beckett Howorth, New York, Discussion by S Kleinberg New York Armin Klein Boston
- Arthroplasty of the Hip Joint**—Alexander Gibson, Winnipeg, J S Batchelor London, Discussion by Paul C Colonna Philadelphia
- Arthroplasty of the Knee Joint**—J S Speed, Memphis Philip C Trout Roanoke J Edouard Samson Montreal Discussion by Reginald Watson-Jones, London
- Changes in Elastic Adipose Tissue with Advancing Years**—J G Kuhns, Boston A W Farmer, Toronto
- Physiological Blocking of Flail Joints**—Alberto Inclan Havana, Discussion—Fremont Chandler Chicago
- Fracture-dislocation of the Pelvis**—Frank W Holdsworth, Sheffield H Earle Conwell, Alabama
- Developmental Coxa Vara**—A B Le Mesurier, Toronto, Discussion by W T Green Boston
- Congenital Dislocation of the Hip Joint**—Juan Farill, Mexico Fred C Durbin, Exeter, Discussion by Henry R McCarroll St Louis
- Arthrodesis of the Ankle Joint**—W Edward Gallie Toronto
- Oestrogens and Bone Formation in the Human Female**—Mary S Sherman Chicago C Howard Fletcher Chicago Fuller Allbright Boston, Arthur Ham Toronto
- Congenital Discoid Meniscus Results of Meniscectomy Knee Joint Changes after Meniscectomy**—Ian S Smilie Edinburgh John C Charnley, Manchester, T J Fairbank, London Joseph S Barr Boston
- Cervical Fractures and Fracture-dislocations**—William A Rogers, Boston, W G Turner Montreal William Cone Montreal E A Nicoll, Mansfield Nottingham
- Organization of an Accident Service**—W Gissane, Birmingham England, J Heberling, Pittsburgh
- Presidential Address**—Robert I Harris Toronto
- Undergraduate Teaching in Orthopaedic Surgery**—Bruce Gill, Philadelphia, George Perkins, London
- Operative Approaches to the Shoulder Joint**—Le Roy Abbott, San Francisco, George Bennett Baltimore
- External Fixation in Orthopaedic Surgery**—J R Naden Vancouver, Discussion by E C Janes Hamilton, John R Moore Philadelphia
- Fractures of the Shaft of the Femur**—E Harlan Wilson Columbus, John C Charnley, Manchester
- Denervation of the Elbow Joint for the Relief of Pain**—James E Batemen, Toronto J Albert Key, St Louis
- Pedicled Nerve Graft**—F G St Clair Strange, Folkstone, England
- Elephantiasis with Congenital Bands in Children**—A W Farmer, Toronto H B Macey, Temple Texas
- Scoliosis with Paraplegia**—K G McKenzie, Toronto F P Dewar Toronto Arthur Steindler, Iowa City
- Paper by Sten Friberg, Stockholm, Sweden
- Nuffield Fellows and Travelling Fellows in Orthopaedic Surgery**—The appointment of ten Nuffield Fellows and two Travelling Fellows in Orthopaedic Surgery was recorded in the last issue of this Journal. Mr James Wishart, first assistant at the Robert Jones and Agnes Hunt Orthopaedic Hospital, has been appointed a third Travelling Fellow. All these surgeons are to be met on arrival in New York by the president of the American Orthopaedic Association. Thereafter they will be received in the clinics of New York Boston Philadelphia Baltimore, Washington Quebec Montreal Toronto, Detroit, Ann Arbor Chicago St Louis and Rochester. A six weeks tour of American and Canadian orthopaedic centres has thus been planned, travelling has been facilitated, generous hospitality has been arranged and expenses are being defrayed by American and Canadian friends of Britain. We trust only that these young British surgeons will seal once more, in their own generation, the bonds of friendship which already exist in a former generation.

## GREAT BRITAIN

### ORTHOPAEDIC SECTION OF THE ROYAL SOCIETY OF MEDICINE

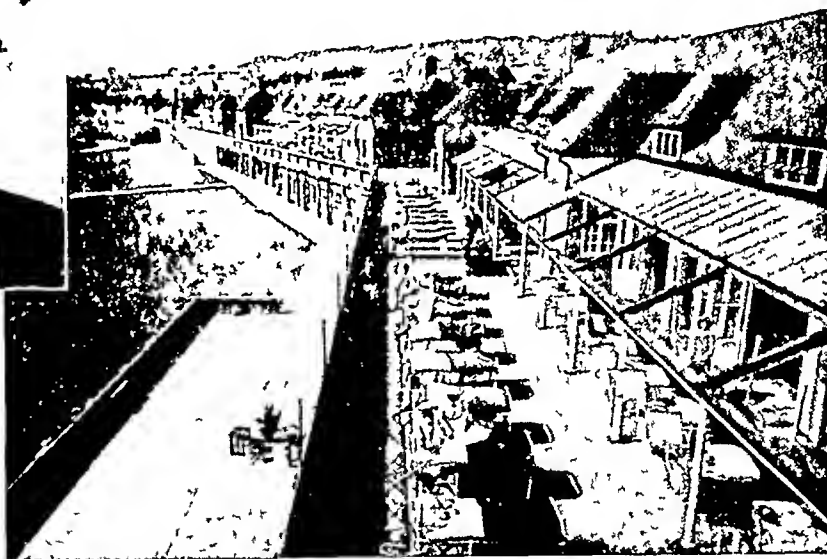
A well-attended meeting of the Orthopaedic Section of the Royal Society of Medicine was held in the late summer 1947 under the presidency of Mr V H Ellis at the Lord Mayor Treloar Hospital, Alton, when a clinical demonstration was arranged by the medical superintendent Mr Stanley Evans. Cases of Britain's ischio-femoral arthrodesis were demonstrated by Mr Langston. Professor T P Kilner read a paper on Plastic Surgery in Relation to Orthopaedic Surgery.

## Contributions of the late Sir Henry Gauvain to Orthopaedic Surgery

Sir Thomas Laubant said that when Gauvain was appointed to take charge of the hospital in 1908 there were definite signs of a swing from the radical to the conservative treatment of non-pulmonary tuberculosis. In the same year one of Gauvain's teachers, the late Sir Anthony Bowlby, published a paper on tuberculosis of the hip joint, based on 900 cases under twelve years of age treated at the Alexandra Hospital. He condemned operative treatment which at that time was almost universally adopted and showed that better results could be achieved by conservative methods. Gauvain was an enthusiastic advocate of these methods. The first of many papers was written in 1910 in collaboration with Dr Calvé and dealt with the treatment of tuberculous abscesses by aspiration instead of incision. Many of his most valuable publications dealt with general or adjuvant treatment in which he did pioneer work. He supported the idea that tuberculous arthritis was no more than a local manifestation of generalised infection. Heliotherapy had been adopted earlier in the century by Bernhard and by Rollier, but quite independently Gauvain was convinced of the value of sunbathing. He often paid tribute to the value of this method of increasing the powers of resistance of the patient. He insisted on the need for graduation of exposure and insisted that exposure in the shade was no less necessary than exposure to the sun. He stressed the value of alternation of stimuli. Sun treatment was allowed only under the supervision of a specially trained sister. He was convinced of the psychological value of this treatment.



Grand Terrace  
Lord Mayor  
Treolar Cripples  
Training College  
and Hospital and  
the late Sir Henry  
Gauvain Medical  
Superintendent,  
1908-1945



Open-air treatment was carried out in all weathers. Believing that sea-bathing and a change of climate would benefit selected cases he persuaded the Trustees to open a branch at Hayling Island. He found however that while most cases responded well some were affected adversely and constant care was necessary. Sea-bathing was considered valuable even for recumbent cases but elaborate precautions were taken to avoid chill by the use of windscreens, braziers and hot meals. With the support of the Medical Research Council he collaborated with Sir Leonard Hill and Dr Argyll Campbell in carrying out metabolic researches which showed that exposure to air had a much greater influence than exposure to sun and proved that the two together might increase the metabolic rate by as much as 40 per cent.

Gauvain took a leading part in the introduction of celluloid splints for the later treatment of tuberculous cases. The celluloid solution was rendered non-inflammable by mixing with calcium chloride. He was impressed by the work of Finsen and by the use in Denmark of artificial light. He went to Copenhagen to study their methods. It was not until after the First World War that he was able to open a Light Department fully equipped with all the latest apparatus and with a sister in charge who had been sent to Denmark for special training.

He was a pioneer in the development of hospital schools insisting on the importance of discipline and full occupation of the time of the patient with work and play. Occupational therapy had been a feature

at the Treloar Hospital for many years especially among older girls in whom it served both as diversion and as training for later employment. He also started one of the first crippled boys' colleges where they were taught to earn a living. To sum up, Gauvain took a leading part in introducing all the features which now as a matter of course were included in the modern country hospital.

Sir Thomas Fairbank said that in one paper published in the *Lancet* November 16, 1918, Gauvain described a method of testing for pathological activity or quiescence of arthritis in tuberculous hip disease. If the condyles of the femur were grasped by one hand, the head of the bone could be rotated in the acetabulum. When this movement was checked, further sharp rotation was followed instantly when disease was active by protective spasmodic contraction not confined to the muscles about the joint, but extending to the abdomen where it was felt easily by the palm of the other hand placed above the pube. Gauvain also pointed out that if disease was not quiescent this rotation of the femur with slight force was transmitted to the pelvis and the iliac spines.

I cannot conclude these remarks, said Sir Thomas, without referring to the exceptional charm of Henry Gauvain's personality which endeared him so much to all with whom he worked. Henry Gauvain made this hospital *he was the hospital*. The happy and optimistic atmosphere that he engendered and which was evident in every member of the staff, infected the patients and played an important part in their progress and recovery.

**Orthopaedic Surgery in Rheumatoid Arthritis**—*Mr. Alexander Law* (London Hospital) on January 14, 1948, emphasised the importance of undertaking reconstructive surgery before joint destruction was complete and before serious atrophy of muscles and ligaments had developed. He described the indications for excision of the acromion process in rheumatoid arthritis of the shoulder joint, for excision of the head of the radius with synovectomy in certain cases of arthritis of the elbow, for complete arthroplasty of the elbow joint, for excision of the lower end of the ulna by which to restore radio-ulnar and wrist movement and for arthroplasty of the hip joint by the Smith-Petersen vitallium-mould technique. He emphasized the necessity for shaping congruous joint surfaces by means of special instruments, and for creating a large acetabulum, and said that success depended not only upon careful and experienced operative technique and an intensive post-operative regime but upon willingness to repeat operative procedures a second or even a third time on the same joint of the same patient. There was no short cut to success. It was pointed out that a satisfactory arthroplasty of the knee joint had not yet been developed but that recent work showed promise. In the treatment of fixed kyphotic deformities of the spine, especially in spondylitis ankylopoetica, spinal osteotomy by resection of the posterior neural arch and facets was worth undertaking.

#### **Serious Limitations and Erroneous Indications of Biopsy in the Diagnosis of Bone Tumours—**

At the meeting held on January 16, *Dr. James Brailsford* urged that punch or drill biopsy of bone tumours was unreliable and that even open biopsy was misleading and led to serious error. He suggested that there might be radiographic evidence that biopsy caused general dissemination. Radiographic diagnosis particularly when based on serial examinations was considered to be much more reliable. In the course of subsequent discussion *Dr. Brailsford's* dogmatic views were found to be generally unacceptable. *Dr. Frank Ellis* pointed out that radiologists varied in their competence no less than pathologists. Serious misinterpretation might arise from radiographic examination just as readily as from pathological examination. He believed in fact that errors after biopsy were infrequent. *Mr. W. D. Collart* said that diagnosis must always be based on the correlation of clinical, radiographic, and pathological evidence.

**Curare (Intercostrin) in the Treatment of Acute Anterior Poliomyelitis**—A film by *Dr. Nicholas S. Ransohoff* (New York) which had been brought to this country by *Sir Morton Smart* was introduced by *Sir Reginald Watson-Jones* at the meeting held on February 3, 1948. *Dr. Ransohoff* accepted the evidence of *Plato-Schwartz* that in acute anterior poliomyelitis there was widespread muscle spasm and believed that such spasm was responsible for dysphagia, respiratory embarrassment and early onset of deformity. By injecting curare the spasm was relieved. *Sherrington's* law of reciprocal innervation was re-established and the pathological stretch reflex was obliterated. The dosage employed was 0.9 units per kilo of body weight every eight hours for the first twenty-four hours, the dosage thereafter being increased, if there was no adverse reaction, to 1.5 units per kilo of body-weight every eight hours. Intra-muscular injection was continued until all evidence of muscle spasm had disappeared.

The essential principle of *Ransohoff's* treatment was not simply to give curare injections, but to make use of such injections in order to institute passive stretching, exercise, weight-bearing and ambulation at the earliest possible moment. The exercises and movements were started within twenty-four hours of admission. At three separate intervals during the first three hours after each day-time dose of curare every joint of the body was put through as complete a range of movement as possible. All muscles were stretched in the attempt to re-establish normal muscle length. The patient was put on his feet as early as possible, no attempt being made to avoid fatigue. Throughout the hours that joints and muscles were not being stretched the patient was made to exercise with parallel bars, specially constructed chair-trapeze, mariner's wheels, bicycles and every type of apparatus. The patients were always busy.

It was emphasised that no claim was made to have established a cure for anterior poliomyelitis but that this treatment gave better results more quickly than any other method. In a series of twenty-nine patients no fixed deformities or contractures developed. Five patients with bulbar paralysis responded in a surprising manner to adequate doses of curare, the relief being attributed to relaxation of spasm of the accessory muscles of respiration and the diaphragm. Dysphagia responded immediately.

Sir Reginald Hatson Jones (London) said that although he had introduced the film it must not be thought that he accepted Ransohoff's principles. He quoted the words of Voltaire "I utterly disagree with what you say, but I would defend to the death your right to say it." He thought that further electromyographic investigation was needed into the question of spasm in poliomyelitis and the extent to which spasm was an important factor calling for special treatment. Further evidence was needed before it could be accepted that treatment by the injection of curare altered the prognosis and improved the outlook. That part of the treatment which insisted upon early mobilisation and weight-bearing passive stretching despite pain and exercise despite fatigue was in startling contrast to the principles advocated by Hugh Owen Thomas and Robert Jones. It might be that in the past we had emphasized too much the importance of protecting paralysed muscles. It might be that avoidable joint stiffness had sometimes been allowed to develop. It was possible that earlier mobilisation and ambulation was advisable. But he would need much more than the evidence of this film to persuade him that fatigue and exhaustion of weak and partly paralysed muscles was desirable. Still more did he feel revulsion amounting almost to horror when he saw painful joints and muscles being stretched and forced despite the agonised protests of the patient.

Professor H. J. Seddon (Oxford) agreed that deformity after poliomyelitis was probably due to the development of contractures rather than to muscle imbalance *per se* though the latter was of course a source of deformity. If this notion was correct then maintenance of a full range of movement was of great importance. The treatment of poliomyelitis had been dominated in this country by the belief that paralysed or paretic skeletal muscle was in so delicate a state as to require prolonged rest. There was no longer any doubt that denervated muscle did not degenerate as did say, a divided nerve. It merely atrophied and putting a paralysed muscle through its full range was no more harmful than stretching a normal muscle, though maintenance of a muscle in an overstretched position was clearly harmful whether the muscle was denervated or not.

If it was accepted that preservation of mobility was necessary we were faced with the difficulty of how to achieve it despite limitation by pain. Dr Ransohoff believed that pain was due to muscle spasm and that if spasm could be abolished the pain would also be relieved. But there was no clear evidence that a motor neurone disturbance causing muscle spasm also caused pain. In spastic paralysis painful limitation of movement did not occur except in late neglected cases where contractures had been allowed to develop. It was much more likely that pain was the cause of spasm. Unfortunately we knew very little about the cause of painful phenomena in poliomyelitis except that extensive changes in the posterior root ganglia had been found with some frequency in fatal cases as well as in experimental disease. Muscle spasm though by no means a constant feature of the disease was very real and could be demonstrated electromyographically; it might be independent of the pain or it might be caused by it. In either case it was difficult to see how curare acting on the motor end-plates could relieve it. Did it in fact do so?

Professor Seddon said that the cases he had seen in Dr Ransohoff's clinic in New Jersey had impressed him most favourably but it so happened that at that time all were past the acute phase of the disease and none was receiving curare. He had been told by other surgeons who had seen manipulations after the administration of curare that patients suffered very considerable pain. The agonised expressions shown in this film were disturbing. He could not help questioning the efficacy of the drug as a remedy for painful limitation of movement in poliomyelitis and believed that the treatment derived its success more from the determination of physiotherapists than from the action of the drug.

There was now little doubt that in poliomyelitis there was disorder of reciprocal innervation; the electromyographic evidence was convincing. Unfortunately in this country we had not been able to assemble the apparatus in time to make observations during the recent epidemic. Dr Ransohoff claimed that curare restored the normal reciprocal activity of antagonistic muscles but unless the drug had some fairly powerful central action it was impossible to see how it could act in this way.

Dr Ransohoff's second argument was that patients should be got out of bed as early as possible if they were bedridden for many months they forgot how to walk. At Oxford during the recent epidemic patients had been allowed up much earlier than had formerly been considered safe but with nothing like the rapidity favoured by Dr Ransohoff. In every case a careful watch had been kept for deterioration in muscle power. Slight decrease in power had sometimes been observed in such muscles as the abductors of the hip. Yet in these cases slackening of the pace arrested the deterioration and in almost all cases there had been gradual increase in power whether weight-bearing was allowed or not. This was hardly the occasion for discussing the rather complicated phenomena of recovery from paralysis in poliomyelitis.

but he thought that Dr Ransohoff's arguments in favour of early ambulation were much nearer the mark than the slavish enforcement of bed-rest that most of us had practised

Dr Ransohoff's last point that very early active exercises should be instituted, was altogether unsound. If recent experience in the treatment of meningitis was any guide then the presence of protein in the cerebro spinal fluid was an indication of persistence of active inflammatory changes in the cord and meninges. In poliomyelitis protein might be found as late as eight weeks after the onset of the disease and it hardly seemed rational to encourage activity in the anterior horn cells until after the acute process had subsided.

**Clinical Meeting, Section of Orthopaedics, March 1948**—Mr Nissen showed a case of *congenital bowing of the tibia* in which pathological fracture had been treated successfully by massive posterior bone grafting. Mr T. H. Meyer showed a most successful *arthroplasty of the knee joint* in a woman aged fifty five years with active rheumatoid arthritis whose other knee had been arthrodesed. No tissue had been interposed between the bone ends. Care had been taken to remove the back of the femoral condyles. The result showed unusually good stability, and a range of movement from full extension to right angled flexion. Mr H. L. C. Wood showed a case of *idiopathic hypertrophy of the mandible*. Mr George Bonney reported the result of treatment by immobilisation in plaster of *Sinding-Larsen-Johansson disease of the patellar apices*. One knee was immobilised and on that side the discrete fragments had fused and the symptoms were relieved. The other knee was left free, symptoms persisted and radiographs showed that the discrete osicles had not fused with the main centre of ossification. A number of cases of *neoplasm of bone* were shown including a reticular-celled sarcoma of the humerus by Mr W. D. Coltart for which local excision was advised; a synovioma of the ankle joint by Mr Kessel, and various obscure tumours by Mr Hywel Davies and Mr Robb.

### Rupture of Intervertebral Discs in the Cervical Region

In the Section of Neurology of the Royal Society of Medicine, on March 4, 1948, Dr Russell Brain opened a discussion on rupture of the cervical intervertebral discs. He outlined all the causes of nerve root irritation due to lesions of the spinal intervertebral joints, and reviewed ten proved cases of cervical disc retropulsion.

**Pathological Features**—The frequency of retropulsion of a disc was greater in the cervical and lumbar regions than in the dorsal region by reason of the mobility, lordosis, and exposure to trauma. The earliest resulting changes were vascular in origin—the veins being affected first. The problem in the cervical spine differed from that in the lumbar spine not only because cervical roots were shorter but because there might be involvement of the spinal cord as well as of nerve roots. Ten of Dr Brain's cases of ruptured cervical intervertebral discs had been verified at operation—nine by Mr Northfield and one by Sir Hugh Cairns: two had root signs alone, eight showed evidence of pressure on the spinal cord. Only in two patients had injury been a possible factor: one other occurred during pregnancy, and seven were associated with cervical osteoarthritis. In the traumatic group congenital weakness of the disc might be a factor, one patient had previously suffered from sciatica. The group of cases with osteoarthritis were older: in these patients compression might arise partly or wholly from bone. The level involved was C 3-4 in one, C 4-5 in two, C 5-6 in six, and C 6-7 in one.

**Clinical Types**—Four clinical types could be distinguished: 1) acute onset of severe pain with root signs; 2) insidious onset of severe pain, sometimes intermittent, with root signs; 3) insidious onset with root and cord signs; 4) insidious onset with cord signs alone. Root pain was shooting or gnawing in character, aggravated by movement of the neck and upper limbs, and by coughing. There might be numbness or tingling in the corresponding dermatome. Sensory loss was patchy and limited in area. Reflexes might be diminished or lost. Fasciculation of muscles might be seen but weakness and wasting were uncommon. Four patients showed the Brown-Sequard phenomenon and in four there was bilateral cord pressure with greatest involvement of the pyramidal tracts and little involvement of the sensory tracts. There was abnormality of the cerebro-spinal fluid in seven of the eight cases, and myelography showed a filling defect in every case in which it was carried out.

**Treatment**—The essential treatment was immobilisation in bed with or without skull traction or the use of a plaster or leather cervical collar. Operation should be reserved for cases with much wasting or with evidence of cord compression.

**Review of thirty-seven cases**—Mr G. C. Knight pointed out that pain seldom reached the distal limit of a dermatome. It might be referred over the front of the chest to the precordial area. Compression of the seventh cervical root caused severe precordial pain which was sometimes mistaken for cardiac angina. Pain was usually provoked by homolateral flexion of the neck, sometimes by extension and not always by vertical compression. Electromyography might be useful in diagnosis. The best treatment is a long 'waiting list,' said Mr Knight. Manipulation was dangerous. Rest was advisable in the position of

greatest comfort—usually hetero lateral flexion. Operation was indicated only when conservative treatment failed. If the nerve root only was involved hemilaminectomy gave sufficient exposure but if there was evidence of cord pressure laminectomy and a transdural approach was advisable. Mid-line protrusions should not if possible be operated upon. He had records of thirty-seven patients twenty-nine with root symptoms and signs four with evidence of pressure on half the cord and four with mid-line protrusions affecting both sides of the cord.

**Review of forty-six cases—***Dr Haden Turner* had studied forty six cases forty-five of which had been followed until all pain was relieved. He relied on bed rest with the head supported with pillows. Relief came within three weeks. Paraesthesia lasted longer than pain. He stressed the importance in diagnosis of dysesthesia of the index finger pain on cervical movement and signs of involvement of the seventh cervical root.

**Anatomical Studies—***Mr John E. O'Connell and Dr H. Coombs* reported an anatomical study which showed that the lumbar intervertebral discs were twenty to twenty-five times as heavy as the cervical discs. He distinguished four clinical types of cervical disc lesion: 1) cervical and brachial pain with symptoms and signs in the distribution of one cervical root and with a good prognosis; 2) cord compression often coming on suddenly after vague cervical pain; 3) severe tetraplegia from compression of the cord after trauma; 4) cervical stiffness after injury with signs resembling those of amyotrophic lateral sclerosis.

**Radiographic Studies—***Dr J. H. Bull* mentioned two anatomical characteristics of the cervical spine: 1) the relative smallness of the intervertebral discs and 2) the presence of neuro-central joints. The joints between the skull and atlas and between the atlas and axis lay in front of the emerging nerve roots. The homologues of these joints in the rest of the cervical spine were the neuro central joints which also lay in front and the ordinary lateral joint between neural arches behind. The importance of directing the rays slightly upwards in taking antero posterior radiographs of the cervical intervertebral spaces was emphasized. Oblique projections were necessary to visualise the lateral joints.

## ROYAL COLLEGE OF SURGEONS OF ENGLAND

**Elections ad eundem of Professor T. P. McMurray and Mr S. Alan S. Malkin—***Mr T. P. McMurray* who recently retired from the chair of orthopaedic surgery in the University of Liverpool and *Mr S. Alan S. Malkin* of Nottingham, president of the British Orthopaedic Association, both Fellows of the Royal College of Surgeons of Edinburgh, have been elected *ad eundem* to the Fellowship of the Royal College of Surgeons of England.

**Lectures in the Royal College of Surgeons—**Throughout April, May and June 1948, Lectures on Anatomy, Applied Physiology and Pathology will be given daily in the College. On June 14 *Mr Eric Lloyd* will lecture on Fractures in Childhood and on June 15 *Sir Thomas Fairbank* will lecture on Abnormalities of the Skeleton. The statutory and other lectures given during February and March included:

February 6	Repair of Tendon Injuries in the Hand—Hunterian Lecture—Professor R. G. Pulvertaft
6	Reactions of Bone to Injury—Professor S. L. Baker
12	Bone Cartilage and Fascia Transplants—Mr Rainsford Mowlem
16	Skin Flaps—Indications and Technique—Sir Harold Gillies
17	Treatment of Skeletal Tuberculosis—Hunterian Lecture—Professor M. C. Wilkinson
18	Free Skin Grafting—Methods and Application—Mr A. B. Wallace
18	Penicillin—Sir Alexander Fleming
20	Burns and their Early Treatment—Mr R. P. Osborne
25	Hand Injuries—Mr J. N. Barron
25	Actinomycosis—Mr Zachary Cope
26	Hand Deformities—Mr J. B. Cuthbert
March 10	Manifestations of Boeck's Sarcoid—Erasmus Wilson Demonstration—Mr R. W. Raven
12	Recent Advances in the Treatment of Arm Amputations: Cineplastic Surgery and Arm Prosthesis—Arris and Gale Lecture—Mr Leon Gillies
15	Acute Uraemia—Arris and Gale Lecture—Dr E. M. Darmady
22	Fractures of the Spine—Sir Reginald Watson-Jones
24	The Pectoral Girdle—Arnott Demonstration—Mr R. J. Last
25	The Knee Joint—Arnott Demonstration—Mr R. J. Last

**Flexor and Extensor Retinacula of the Wrist and Ankle—**In a Hunterian Lecture *Mr H. F. Lunn* said that the difference in function of the flexor and extensor retinacula depended on the fact that the flexor tendons when in action thrust against the underlying bone whereas the extensor tendons thrust against the overlying retinacula. Consequently surgical division of the extensor retinacula might be expected to weaken the extensor power of ankle and wrist. The length of synovial sheath of a tendon

depended on a number of factors of which the most important was change in the direction of the tendon. Hence the longest sheaths in the hand were those for the tendons of the most divergent digits. Another factor was the crossing of one tendon by another—for example the long sheath of *tibialis posticus* which was crossed by the *flexor digitorum longus*, and of the *extensores carpi radialis* which lay beneath the *abductor pollicis longus* and *extensor pollicis brevis*. Beneath the retinacula, the mesotendon with its contained blood-vessels was attached to that surface of the tendon least subjected to friction. Hence at the wrist the mesotendon was attached to the ulnar surface of the *flexor pollicis longus* tendon but to the radial side of the *flexor tendons* of the fingers. The lecture was illustrated from dissections in the Anatomical Museum of the College some of which had been beautifully prepared by Dr D. H. Tompsett.

### THE HUNTERIAN SOCIETY

It is customary for the Hunterian Society to celebrate each year within the boundaries of the City of London the day of birth of John Hunter—February 13 or possibly February 14. This year, austere conditions made it necessary to substitute for the usual dinner a simple evening reception which was held in the West End within a few hundred yards of St George's Hospital. Mr Roche, president of the Society, in receiving the guests and proposing the traditional toast said that "if Hunter had lived to day he would probably not have been born at all. He was the youngest of ten children and in these days families of ten are hard to find. Mr Roche wondered what might have been the reactions of John Hunter in attending a cocktail party in his honour 150 years after his death. Despite the temperance of his later years he might well have applied one of his favourite expressions, 'Don't think try it.' In honour of the celebration the Society displayed its treasures including Hunter's manuscripts, his walking stick (the handle of which was lost in the London blitz), his watches, balances, silver-rimmed spectacles, brass dispensing instruments, and the large repeater watch which was presented to him by the staff of St George's before the quarrels and before the stage when his life was 'held in the balance by any who cared to anger him'.

An account of the influence of John Hunter on the development of orthopaedic surgery is included in the Historical Reviews of this number of the Journal, but it is impossible within the compass of a few pages to include all the dramatic features of the life of this great man. Why was his marriage delayed? Was it not rather an financial problem, or was it in consequence of his experimental auto-innoculation with the gonococcus—a study complicated by unexpected infection with the spirochaetes of syphilis? What was his relationship with his brother William Hunter? Was it represented accurately by the letter in which he wrote: 'Dear Brother to-morrow morning at eight o'clock and at St James' Church I enter into the Holy State of Matrimony. As that is a ceremony which you are not particularly fond of I will not make a point of having your company there.' What was the attitude of his wife—a lady noted for her beauty, wit and accomplishment—a social figure in the world of art? When her husband at his own expense sent a young man to Greenland to bring back a whale and continued to add to his ever growing collection so that 'the family were literally forced into the street'? What was the reason for the burning of Hunter's manuscripts after his death by his brother-in-law, Everard Home? Was it strictly in accord with Hunter's last instructions or was it the result of piety, jealousy or plagiarism? The reader is referred to the vast volume of accumulated literature which breathes through every page the spirit of an individualist and a great pioneer.

### DESTRUCTION BY FIRE OF THE ROBERT JONES AND AGNES HUNT ORTHOPAEDIC HOSPITAL, OSWESTRY, SHROPSHIRE

In the last number of this Journal, almost at the moment of publication, certain pages were put through the press a second time in order to include a stop-press account of the disastrous fire which destroyed the greater part of the Robert Jones and Agnes Hunt Orthopaedic Hospital on Tuesday, January 27, 1948. On a dark and raining night a fire started in the Dispensary. There was a west wind and the flames spread with alarming rapidity along the communicating corridor, destroying every open air ward in turn. Six hundred patients, most of them immobilised in splints, frames, and plasters, were pushed to positions of safety and protected so far as was possible by coats and Mackintoshes, from the deluge of rain. All six hundred beds and trolleys were lifted by hand over water hoses, debris and other obstacles, and pushed one mile along the main road by nurses and sisters who proved expert in their unaccustomed task. There was no single casualty. The greatest personal disaster was that the dentures of two patients were interchanged, thus leading to much confusion! Fire brigades, assembling from many quarters, found it impossible to control so widespread a series of fires. In the face of the wind the last of the scattered but intercommunicating buildings was destroyed. At about this moment the wind veered round into precisely the opposite direction. Thereupon the fire spread eastward along the main corridor and threatened the remaining wards, the operating theatres, radiographic department and nurses' home. To the credit of the resident medical staff, which includes surgeons not only from England and Wales but from Australia, Canada and the United States, a new form of manipulative technique was



applied. A ten yard gap was torn in the structure of the main corridor. Slates, felts and beams were rained by hand in the face of advancing flames. Spread of the fire was arrested. No operation was ever more successful. In consequence of their efforts enough was saved to restore the functions of this great hospital within five days. It is true that the number of beds was reduced. It is true that for a long period there was no hot water and no light. But routine duties were restored, operations continued, surgeons scrubbed up in cold water, patients were fed—not from the dietetic department which exists no longer but from army tent kitchens set up in neighbouring fields. The destroyed sites



Middle of the night



Next morning

are cleared already. A rebuilding committee started work the next day. The shape of new wards, physiotherapy department, administrative block and concert hall can now be determined. No thought of an Appeal Fund was entertained but within twenty-four hours the flow of bank-notes, cheques, postal orders and other donations from former patients and supporters, ranging from many hundred pounds to one or two shillings, was so great that a rebuilding account has been opened by John Menzies, Secretary-Superintendent of the hospital. The only comment made by Dame Agnes Hunt, who at the time was a patient herself, was: 'I never wanted too big a hospital.' Her spirit and the spirit of Robert Jones survives; indeed it has gained new impetus.



## SURGEONS' CONFERENCE OF THE MINERS' WELFARE COMMISSION, 1947

## Redevelopment of Muscle Function

Mr Nicoll (Mansfield) introducing a discussion on the redevelopment of muscle function after injury said that there were four important properties of muscle each of which had particular significance 1) power of contraction 2) velocity or speed of contraction 3) co-ordination, 4) endurance

**1 Muscle power**—This was defined as the equivalent of horse-power in an engine or what was popularly known as strength. It was measurable and always diminished during immobilisation in plaster whether the muscle was damaged or not and whether exercises in plaster were carried out or not. Exercises certainly minimised falling off in muscle power but they never abolished it. There were certain physiological facts which had a bearing on treatment. A muscle graduated its power output according to the load. According to Sherrington's law of muscle action, each individual unit contracted to its fullest extent or not at all and therefore the process of adapting power-output to load could be achieved only by varying the number of contractile units brought into play at any given moment. The accurate method of measuring muscle power was to measure the maximum load against which the muscle was capable of working. Another physiological fact of importance was that the efficiency of a muscle fibre varied with the extent to which it was stretched so that it became mechanically less efficient as it shortened. This had a bearing on the technique of resisted exercises.

Most Rehabilitation Centres now employed resisted exercises in order to build up muscle power. There had been criticism of this technique so that it was appropriate to review the principles on which it was based. In the first place there was the analogy with unstriated muscle which always hypertrophied providing that the resistance against which it worked was increased gradually. In prostatic obstruction, chronic intestinal obstruction and high blood-pressure enormous hypertrophy occurred in the bladder, bowel and left ventricle respectively. The two factors concerned were the gradual nature of the obstruction and the fact that the muscle was endeavouring to overcome it almost continuously. On the other hand if obstruction was acute then instead of hypertrophy there was passive stretching with atrophy. Secondly, there were the well known occupational examples of dock-porters developing enormous shoulder muscles and footballers developing hypertrophy of the quadriceps and calf muscles. In other words muscle hypertrophy was a response to unusual demands over a long period. In America they had carried resistance exercises a stage further and now preached that high resistance exercises develop true power whereas low resistance exercises develop the property of endurance which was quite a different thing.

He claimed that there were sound reasons for the adoption of graduated resistance exercises in building up both power and endurance in muscles. When these exercises had caused ill effects it was not because the principle was wrong but because the technique had been faulty. Because morphine in excessive doses killed people or even in normal doses occasionally killed very feeble people there was no reason for prohibiting the use of morphine in medicine. The apparatus originally developed at the Miners' Rehabilitation Centre at Berry Hill for graduated resistance exercises was cumbersome and mechanically inefficient. A new type of apparatus had now been developed at the Oakmere Hall Miners' Rehabilitation Centre which was better in all respects.

**2 Velocity or speed of contraction**—This was a property of muscle, partly inherent and partly acquired by training. The highest speeds of contraction were observed in insects: the wings of certain insects moving so rapidly that they created sound waves. Although the muscles of human beings operated at a much slower speed much improvement could be achieved by training. The virtuoso pianist was at least two species removed from the rest of us (including the virtuoso surgeon) in this matter of speed. Mr Nicoll was ignorant of the physiological basis of this property but presumed that it had something to do with the speed of nerve impulse and possibly with lowered resistance at synapses through which it passed. It was certainly amenable to training: the mechanism of which like memory would seem to be related to facilitation at the synapses. The importance of this property apart from enabling people like Horowitz to play piano concertos was that it was the basis of agility which was important to miners who had to be prepared to move quickly in certain circumstances. Agility together with co-ordination was the basis of dexterity and timing which was just as important in work as in sport. Finally the speed at which a muscle like the vastus internus could be brought into play by reflex action was important. If the medial collateral ligament was stretched and the stretch reflex travelled quickly, the protective action of the muscle was exerted before any damage was done and this was often a matter of split seconds. It was therefore an important property to redevelop in muscles particularly those like the vastus internus which maintained protective action on a joint. It was a property that had to be redeveloped by training.

**3 Co-ordination**—The perfect example of co-ordination was in the ballet dancer. Its physiological basis was related to the synergic and antagonistic action of a muscle as opposed to its function as a prime mover. It was therefore dependent on preserving the sensory mechanisms in muscles and ligaments and keeping these mechanisms in training by synergic exercises during immobilisation in plaster. The importance

of co-ordination was that it played a great part in what was known as 'timing'. The skilful miner by proper timing could load a ton of coal on to the conveyor belt with a minimum output of energy just as the expert golfer could drive a golf ball 350 yards down the middle of the fairway with no apparent effort. Like velocity of contraction, this property of co-ordination was responsive to training and like all such human properties it disappeared rapidly when it fell into disuse. Exercises in plaster were therefore of paramount importance as were general exercises for the recumbent patient. These kept the proprioceptive mechanisms and all the complicated reflexes in training.

**4 Endurance**—Physical endurance was defined as the ability of muscles to go on working at high efficiency over a prolonged period. It was another quality fast disappearing in the human race. People who complained, usually from armchairs, that the miners of to-day could not work half as hard as their grandfathers were apt to forget that grandfathers were not half the men great great grandfathers were. In fact we were approaching that stage of human evolution depicted by H. G. Wells' *Man in the Moon* who was capable only of sitting in a chair while his enormous head was sprayed with water to keep his brain cool. Two thousand four hundred and thirty seven years ago a Greek soldier named Pheidippides hearing that his country was about to be invaded by the Persians travelled for two days and two nights climbing mountains and swimming rivers to seek aid from the Spartans. His mission having failed he returned to fight throughout the day in the great Battle of Marathon in which the Greeks were victorious. He then ran 26 miles 385 yards to Athens and having delivered the great news to the city elders dropped dead at their feet. Such feats of endurance are beyond human compass to-day though there are authenticated examples within recent memory of native runners covering a distance equal to that from London to Manchester in forty eight hours. The running footmen of the Middle Ages who ran ahead of their lords to arrange board and lodging (an occupation that might well be revived to-day) also performed prodigious feats of endurance.

Endurance was quite separate from power which depended on the actual number of functioning contractile units in the muscle—in other words bulk. Endurance on the other hand was often associated with lean spare types like Sydney Wooderson and it was physiologically an expression of respiratory and circulatory efficiency in muscle—the ability to get rid of waste products fast enough to prevent the onset of fatigue. It was not power, mobility or even residual deformity that prevented spinal cases from going back to full work—it was the fact that they could only work at normal pace for four hours instead of eight hours so it was worth while trying to find out how to restore this vital property of endurance.

Mr Nicoll had visited France last year to study methods of rehabilitating injured miners. Next time it might be more profitable to study how they trained racehorses! Whatever the secret it seemed obvious that the orthopaedic surgeon who was bent on improving the respiratory efficiency of muscles should not lose sight of the fact that there was also a central respiratory mechanism. Breathing exercises should form part of the treatment of every case. The 'high repetition low resistance' technique of the Americans was worthy of trial but it was far from proved.

Mr A. O. Parker said that muscles varied considerably in their response. His experience in poliomyelitis had been that only certain muscles were favourable for transplantation operations others gave disappointing results however hard one tried. He had noticed surprising hypertrophy in the shoulder and arm muscles of patients compelled to become dependent on crutches—and this was particularly so in children. Hypertrophy in response to extra demand was in fact, almost constant in the growing muscle but he wondered if the same applied to adults.

Mr C. H. Cullen referred to the fact that some muscles wasted much too quickly for it to be a simple phenomenon of disuse. In injuries of the medial collateral ligament of the knee for example wasting of vastus internus was very rapid indeed and it was a matter of urgency to get back the use of the muscle quickly. He agreed that much could be achieved by training and concentration in the matter of individual muscle development. One of his staff was an expert in muscle control and would demonstrate later. He stressed the importance of not overloading the muscle in resistance exercises and referred to Professor Le Gros Clark's findings that if only the muscle sheath and a few nuclei were left the muscle fibre could regenerate.

Mr Leslie Morris doubted if resistance exercises were necessary. He operated on many professional footballers suffering from cartilage lesions and his usual procedure was to put them back in the second team after five weeks. He never prescribed resisted exercises but his patients seemed to get fit and usually played first-class football within three months.

Sir Thomas Fairbank referred to the time honoured use of massage and heat before and after exercise periods in those patients who developed pain due to early fatigue. These agents stimulated intra-muscular circulation and lymph flow.

Mr F. G. St Clair Strange said that under normal conditions there must be some mechanism for inhibiting the full output of muscle power. This restraining mechanism was released in conditions like acute mania

in which normally weak and puny people suddenly became possessed of superhuman strength. He had seen the same thing happen during an experiment on hypnotism at which he had been present. *Mr E. A. Nicoll* in reply, said that hypertrophy in response to extra demand was commonly observed in adults as well as children. This was particularly borne out in paraplegics and one had only to visit Stoke Mandeville to be convinced of it. In reply to *Mr Morris*, he agreed that some patients got fit if they were left to their own devices but only if they were normally active and determined types. In such cases analysis of progressive activities revealed that they were, in fact, subjecting muscles to progressive resistance though without special apparatus. The principle was unaffected and what the surgeon had to do was to apply the principle scientifically and methodically so that apathetic types would get better as well as others. He agreed with *Sir Thomas Fairbank's* views on massage and heat therapy. These agents acted by stimulating the circulatory mechanism in muscle and it was reasonable to suppose that this mechanism improved by being exercised just as did the muscle itself.

**Demonstration**—The discussion was followed by a practical demonstration of resisted exercise technique in which the special apparatus developed at Oakmere Hall was demonstrated. *Mr James Evans* of the remedial staff, concluded by giving an exhibition of muscle work in which he demonstrated power (weight lifting) individual muscle control balancing and co-ordination. This exhibition was conducted with flawless technique and a fine sense of showmanship and was much appreciated by the audience.

### SOUTH-WEST ORTHOPAEDIC CLUB

The first regional meeting of orthopaedic surgeons working in the South-West of England was held at Mount Gold Hospital, Plymouth, on March 6, 1948, with *Mr Charles Kennedy* of Plymouth in the chair. At a preliminary business meeting it was decided to adopt the name 'South-West Orthopaedic Club' in order to indicate the friendly and informal atmosphere which it was hoped would be the keynote of the meetings. *Mr F. C. Durbin* of Exeter was elected honorary secretary. Four short papers were read. **Recent Developments in the Treatment of Rheumatoid Arthritis**—*Mr John Bastow* (Bath) summarised recent important advances, and emphasised the value of biopsy both in diagnosing true rheumatoid arthritis and in estimating the degree of muscle atrophy before arthroplasty or other operative procedures were contemplated. He said that calcium-gold salts were often used and that the danger of unpleasant reactions was minimised by "anti-lewisite". The transfusion of blood of pregnant women appeared to be of some assistance but there was difficulty in obtaining it. Joint lavage helped by clearing out fibrinous debris.

**Arthrography in Congenital Dislocation of the Hip Joint**—*Mr F. C. Durbin* (Exeter) recalled the distinction drawn by Jacques Leveuf between true congenital dislocation and primary subluxation of the hip joint. *Mr Durbin* showed arthrograms demonstrating this difference, and showed slides illustrating the late subluxation to be expected in primary subluxations if a shelf operation was not performed.

**Arthrography as a Diagnostic Aid in Knee Conditions**—*Mr A. E. Jowett* (Taunton) used a radio opaque substance 'pylumbrin'. He injected 10 ccs of 35 per cent solution into the knee joint to demonstrate the shape and form of the synovial cavity in various disorders. A very interesting series of slides was shown. Pylumbrin was quickly absorbed from the knee joint, most of it disappeared within thirty minutes of injection and it caused little or no reaction.

**Results of Intra-articular Injection of Lactic Acid for Osteoarthritis**—*Mr H. Salz* (Plymouth) reviewed the results of lactic acid injection in a small series of sixteen cases. In gross osteoarthritis it did not appear to be of much benefit. In the knee joint when changes were not advanced, good results were obtained. Maximum benefit was usually produced by the second injection. Sometimes circulatory collapse as well as severe pain followed an injection into the hip joint.

**Clinical Demonstration**—Clinical cases were demonstrated at Mount Gold Hospital by *Mr Lillie* and the resident medical officers.

### JOINT MEETING OF LIVERPOOL MEDICAL INSTITUTION AND MANCHESTER MEDICAL SOCIETY, MARCH 4, 1948

**The Backache-Sciatica Syndrome and the Intervertebral Disc**—*Sir Harry Platt* recalled Goldthwait's original case operated on by Harvey Cushing and said that Goldthwait's first conception of rupture of the annulus fibrosus leading to posterior protrusion of the disc substance with pressure symptoms still held good. A warm tribute was paid to the pioneer work of the Boston Medical School, especially of *Mixter* and *Barr* whose original paper had become classical. He did not consider that spinal fusion as well as removal of the disc was necessary provided that there was not a long history of backache extending over many years and that the occupation of the patient was not arduous. Prolapsed disc was the commonest intra-spinal cause of sciatica but he deplored the tendency to believe that all sciatica was due to prolapse.

of a disc the clinical picture of which was characteristic and unmistakable. *Professor Geoffrey Jefferson* said that neuritis could not be dismissed as non-existent and might be the cause of a single attack of sciatica. Approximately one third of these cases cleared up completely with conservative treatment. He discussed the question as to whether a normal disc prolapsed as the result of trauma or whether trivial injury caused prolapse of a disc already softened by disease. The disc could be displaced laterally and anteriorly as well as posteriorly into the spinal canal and it was necessary to be sure that there was not impingement of part of the disc on the nerve root in the foramen. The results of operation were most satisfactory over 80 per cent of his patients subsequently being able to do a full day's work. *Professor T. P. McMurray* urged caution in arriving at assessment of the final value of removing herniated discs. *Mr I. Sutchiff* *ACM* supported hemilaminectomy as the method of choice. *Mr Bryan McFarland* declared that many patients with disc syndromes were cured by complete rest followed by a suspension plaster. *Mr Chandler* warmly supported radical measures. *Dr Smiley* advised full investigation and preliminary conservative treatment before operation. *Dr Lennox Johnston* recorded a personal experience of cure by manipulation. *Mr Sarah Crier* advised operation.

### HUDDERSFIELD MEDICAL SOCIETY

The Huddersfield Medical Society is one of the oldest medical societies in England. It has been continuously in session and in the winter months has held regular meetings every year since 1813. On February 11 1948 *Mr Bryan McFarland* (Liverpool) showed cinematographic records of interesting and unusual orthopaedic cases. Lively discussion followed on the problems of lipodystrophy Legg-Perthes disease of the hip joint congenital club foot and the treatment of destructive gap fractures of long bones.

### BRITISH MEDICAL ASSOCIATION—116th ANNUAL MEETING, JUNE 1948

The 116th annual representative meeting of the British Medical Association will be held in Cambridge from June 25 to July 2 1948. The orthopaedic section will meet under the presidency of *Professor T. P. McMurray* (Liverpool). The vice presidents will be *Mr N. Ross Smith* (Bournemouth) *Mr R. W. Butler* (Cambridge) and *Mr H. A. Brittain* (Norwich). The honorary secretaries are *Mr Bourdillon* of Addenbrokes Hospital, Cambridge and *Mr H. Langston* of Gifford House St Giles Hill Winchester. The programme will include a discussion on the clinical significance and treatment of lesions of the intervertebral discs opened by *Professor Geoffrey Jefferson* (Manchester) and *Mr Norman Capener* (Exeter) a discussion on the operative treatment of fractures and papers on the injection treatment of osteoarthritis by *Mr Grant Waugh* (Sunderland) and on the treatment of osteomyelitis.

Discussions and papers in other sections will include Recent work on Proteins by *Professor A. C. Chibnall* *Dr J. A. V. Butler* *Dr Leonard Colebrook* and *Professor G. Pickering*. Plasma and Blood Derivatives in the Treatment of Burns by *Professor E. C. Dodds*, Physiological Basis of Neuromuscular Disorders by *Sir Henry Dale* and *Dr W. S. Feldberg*. Acetylcholine and Neuromuscular Transmission by *Dr Bernard Katy*. Excitation at the Myoneural Junction by *Dr Andrew Wilson* and Poliomyelitis by *Dr W. Gunn* and *Dr F. W. Bunting*.

### INTERNATIONAL CONGRESS ON INDUSTRIAL MEDICINE, LONDON, SEPTEMBER 1948

The ninth International Congress on Industrial Medicine will be held at Caxton Hall London from September 13 to 17 1948 under the patronage of Their Majesties the King and Queen. The Vice patrons include the Right Honourable *Mr Ernest Bevin* (Secretary of State for Foreign Affairs), *Mr Isaacs* (Minister of Labour) *Mr Aneurin Bevan* (Minister of Health), *Mr James Griffiths* (Minister of National Insurance) *Mr Strauss* (Minister of Supply) and *Mr Gartskill* (Minister of Fuel and Power). The presidents of the Royal College of Physicians and the Royal College of Surgeons will serve as presidents of the Congress. The chairman of the Planning Committee is *Dr Donald Hunter* (London Hospital) and the chairman of the British Organising Council is *Mr T. E. Stowell* (London). The discussions will include biological psychological physical chemical and architectural aspects of environment in industry organisation of industrial medical services, surgical aspects of industrial medicine chemical and thermal burns medico-legal aspects of industrial hazards and rehabilitation after industrial injury. The MacKenzie Industrial Health Lecture will be given by *Mr H. E. Griffiths* on Rehabilitation in Industry. Visits will be arranged to the London Hospital Industrial Health Exhibition of the Royal College of Nursing Queen Elizabeth's Training College for the Disabled Roffey Park Rehabilitation Centre Ministry of Labour Rehabilitation Centre Egham Birmingham Accident Hospital Austin Motors Rehabilitation Centre Mersey Docks and Harbour Board Medical Centre Liverpool. Arrangements can be made with *Miss Mawdesley* Organising Secretary B.M.A. House Tavistock Square, London W.C. 1.

## AN ARTIST'S VIEW OF THE ORTHOPAEDIC SURGEON'S THEATRE

An exhibition of drawings by the well-known sculptor Barbara Hepworth which was of particular appeal to orthopaedic surgeons was held last month at the Lefevre Galleries in London. In former days many of the old masters found interest in the work of medical men. A well-known example is Rembrandt's 'The Anatomy Lesson'. Most surgeons are familiar with the work of medical artists who brave the rigors



'Median' by Barbara Hepworth  
(Peripheral nerve injury operation)



'Reconstruction' by Barbara Hepworth  
(Arthroplasty of the hip)

of the operating theatre to record or illustrate pathological detail and operative technique. In Barbara Hepworth we have an artist of a different type with both stamina and vision who sought to appraise not technical detail but the sincerity, harmony, rhythm, tenderness, and simple drama of the operating theatre. Little perhaps do surgeons realise the classic beauty of their surroundings—a beauty based upon perfect architectural conditions designed for a purpose and a grouping which appeals to the sculptor because of the associated movement of individuals and objects with perfect co-ordination towards one

purpose within a central stage. These drawings seem to reveal the spirit of surgery—the spirit of inquiry, intensity of proper solicitude, power of the craftsman, unhurried activity and energetic poise. For the layman the artist has distilled out of the picture the sentimental and the morbid. In these drawings there is no individual portrayal, but there is in many a sense of the unseen, indeed the sense of the good surgeon himself—always conscious of the unseen person beneath his hands and never callous of his material. Surgeons may or may not feel flattered by these drawings, but they cannot fail to be impressed with their beauty and by the sincerity of the artist.

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### EMPIRE RHEUMATISM COUNCIL

The spring week end course of the Empire Rheumatism Council was held in Apothecaries Hall, Blackfriars Lane, London, in March 1948. Lectures were given by Dr Kersley on Gout, Dr Fletcher on Osteoarthritis, Dr Legner on Spondylitis, Dr Bonham Carter on Still's Disease, Dr Copeman on Sciatica, Dr Savage on Rheumatoid Arthritis, and Mr W. D. Coltart on Orthopaedic Aspects of Rheumatic Diseases.

## NORTHERN IRELAND

### THE NORTHERN IRELAND ORTHOPAEDIC SCHEME

It was an historic day for Northern Ireland in 1940 when Sir David Lindsay Keir, Vice Chancellor of Queen's University, Belfast, called a meeting of representatives of the hospitals and other statutory and voluntary bodies throughout the six counties. The Northern Ireland Council for Orthopaedic Development was established, under the presidency of the Duchess of Abercorn, with the object of developing an orthopaedic scheme for the Province. Sir David, who was elected Chairman of the Council, carried out the wishes of Trustees of the Nuffield Fund for Cripples, who in 1937 had set apart £26,000 for the development of orthopaedics in Northern Ireland, and the Central Council for the Care of Cripples which acted in advisory capacity.

Northern Ireland, comprising the counties of Antrim, Armagh, Down, Fermanagh, Londonderry and Tyrone, with the County Boroughs of Belfast and Londonderry, is peculiarly suited to the development of centralised medical schemes, and this has been recognised by the Parliament of Northern Ireland, which passed a Tuberculosis Act in 1946, centralising the scheme for all forms of tuberculosis. Northern Ireland's population of 1,348,000 is nearly one third that of Ireland as a whole. Belfast, its chief industrial centre, has a population of rather less than half a million, with its University admitting approximately 120 medical students each year. The main industry in the rest of the Province is agriculture. From the point of view of economics and social services, Northern Ireland is on a par with Great Britain, constitutionally being an integral part of the United Kingdom with a Parliament of its own, federal in type, but with certain powers reserved to the United Kingdom Parliament. On the whole, the people are a mixture of Celt and Scot, and many retain the qualities of their Scottish ancestry—hard-working, industrious and thrifty, slow to accept new ideas, but determined in their pursuit of ideas once they have been proved worth while.

Thus in 1941 the Northern Ireland Council for Orthopaedic Development launched its Orthopaedic Scheme. In consequence of the war, the Council was unable to carry out its first objective, namely the establishment of an open-air Orthopaedic Hospital. Instead it set out to provide clinical facilities at the main centres of population throughout the Province. A panel of surgeons was formed, and Sister Gwladys Morris came from the Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, to do her magnificent pioneering work.

From small beginnings at Coleraine and Londonderry, the scheme progressed until now there are eleven clinics under the Council's auspices, with a total of more than 3,000 patients. These clinics are situated at Londonderry, Coleraine, Ballymoney, Ballymena, Ballycastle, Downpatrick, Omagh, and Armagh, and in three Belfast Hospitals. Further extension is planned on a regional basis, so that the whole Province may have access to orthopaedic clinical facilities. In addition, the Council has sought to make arrangements for hospital treatment for its patients. The lack of its own open-air hospital has proved a source of difficulty and delay in arranging effective treatment. However, beds have been made available at various Belfast Hospitals, and in particular at the Ministry of Health Emergency Hospital. Here the Council's visiting orthopaedic surgeons are in charge of their own cases referred from the clinics, and thus the principle of continuity of treatment is maintained. Every effort has been made towards the establishment of an open-air hospital; plans were drawn up, sites were investigated, and the cost was assessed, but the Council was asked not to put the plans into action because the hospital will soon be considered by the Hospitals Authority to be appointed under the new Health Services Act, in relation to the complete needs of hospitalisation in the Province.

The Council has four visiting surgeons—Mr H. P. Hall, Mr Maurice Lavery, Mr Norman Martin, and Mr R. J. W. Withers, and three orthopaedic physiotherapists—Miss G. M. Morris (After-Care Superintendent), Miss M. Fearing, and Miss S. Brown.

The Vice Chairman of the Council is Mr S T Irwin, C B E Under the Executive Committee administration, execution, and organisation of work is carried out by Mrs Doreen McConnell, organising secretary to the Council, with an office staff of three Voluntary Committees have been set up in various areas and members of the Voluntary Aid Detachment give their services in the clinics as part of the orthopaedic team

In aiming to provide a complete orthopaedic scheme, the Council has interested itself in all aspects of the care and cure of cripples special education, vocational training, rehabilitation and general welfare A continuous effort has been made to acquaint the general public with the need for orthopaedic treatment by which to prevent and cure crippling diseases and defects Talks have been given and films are shown all over the country

Noteworthy events have been the recent acceptance of the Presidency of the Council by Her Excellency the Countess Granville D C V O, wife of the present Governor of Northern Ireland the incorporation of the Council the training at the Wingfield-Morris Orthopaedic Hospital of Mr Norman Martin, now one of the Council's visiting orthopaedic surgeons, and the servicing at Purdysburn Fever Hospital of the poliomyelitis cases during the 1947 epidemic

The Northern Ireland Council owes much to many individuals in Northern Ireland, to the Trustees of the Nuffield Fund for Cripples and the Central Council for the Care of Cripples and to Sir Reginald Watson-Jones Mr Norman Capener Mr G R Girdlestone, and Professor Mackintosh, who have visited Northern Ireland with the purpose of developing their work

## AUSTRALIA

The next meeting of the Australian Orthopaedic Association will be held in Perth on August 11-12 1948 This will immediately precede the meeting of the Australasian Medical Congress, organised under the direction of the British Medical Association, which meets every third year This is the first occasion that the Congress has been held in Perth The meeting embraces every section of medicine and surgery and there will be a section of orthopaedics under the presidency of Mr Charles Littlejohn of Melbourne The Secretary of the orthopaedic section is Dr A L Dawkins of Perth

## UNION OF SOUTH AFRICA

In South Africa the importance of orthopaedic surgery has been recognised for many years in the University cities of Johannesburg and Cape Town This arrangement of two isolated centres of orthopaedic service continued until comparatively recently when the generous grant from Lord Nuffield stimulated the development of orthopaedic centres in many other cities

In the University of the Witwatersrand in Johannesburg the responsibility for undergraduate and post graduate teaching rested on Mr Fouché who was the first lecturer in orthopaedic surgery Under graduate instruction consisted in the delivery of a course of lectures, extending over two University terms The student was also obliged to attend clinical demonstrations in the Out-Patient Departments of the General and Children's Hospitals For the post-graduate who wished to obtain the Mastership of Surgery with specialisation in orthopaedics a two years course both theoretical and practical was obligatory During the past year Mr Fouché has retired and the University has appointed Mr Edelstein to take over the control of teaching

**Master of Surgery in Orthopaedics, Johannesburg**—Professor T P McMurray (Liverpool) writes "My experience of the Witwatersrand University was gained through invitation to serve this year as external examiner in orthopaedic surgery for the degree of Master of Surgery I found that the instruction and the experience gained by candidates for the examination was in every way excellent During the two years of training the student receives continuous instruction in general surgery from the Professor of Surgery, and in general and special pathology from the Professor of Pathology At the same time he is appointed as clinical assistant to Mr Edelstein Mr Polonsky Mr du Toit, or Mr Moller In these positions he has the opportunity of dealing with large numbers of patients, not only in the out-patient department but also in the wards and operating theatre These unusual opportunities for training are possible only on account of the immense amount of clinical material which is available in the orthopaedic services The clinics include large orthopaedic and fracture departments of the general hospital and the even larger department in the Non-European hospital together with the orthopaedic service of the Children's hospital

"In common with the practice at most large hospitals in Britain fracture clinics are held daily and the work is divided evenly between members of the orthopaedic staff of the hospital Patients requiring long periods of hospital treatment for tuberculous arthritis, infantile paralysis, or congenital deformities are treated in the Hope Hospital which is run under the direction of Mr Edelstein and has the advantages of high altitude and of the enthusiasm of an active staff of nurses and physiotherapists

"The standard of examination for the Mastership of Surgery is very high The tests consist of written sections on general surgery general and special pathology and orthopaedic surgery, together with a



including clinical examination. The University has rightly decided that knowledge of part of surgery alone is not sufficient to qualify the candidate for a Master's degree. It insists upon a satisfactory knowledge of all branches of surgery and surgical pathology. The tests in general surgery were in the hands of Professor Underwood and Professor Brebner. The pathological examination was held in a private ward of the General Hospital where Professor Strahan did not allow his powers of examination to be impaired by the fact that at that time he was a patient himself. No section of general surgery or pathology was left untouched. The marking was fair but firm. As the result of an examination extending over seven days the pass rate was only 25 per cent."

**Orthopaedic Surgery in Cape Town**—In Cape Town Mr Hamilton Bell holds the posts of Lecturer on Orthopaedic Surgery at the University and senior orthopaedic surgeon to the Groot Schur General Hospital. University teaching has been confined to undergraduates and although the University holds examinations for the degree of Master of Surgery a special examination in orthopaedics has not yet been held. Holding the post of assistant surgeon at the Groot Schur Hospital and in charge of the active orthopaedic research department in the University is Mr A. J. Helfet who is also a clinical teacher in orthopaedic surgery.

Long stay patients are accommodated in the Lady Michaelis Home which has been specially designed and equipped for this purpose. The Home which is under the direction of Mr Bell, deals largely with children suffering from infantile paralysis, tuberculous arthritis and congenital deformities. In addition to physical rehabilitation the patients receive school instruction up to the matriculation standard.

The undergraduate student receives adequate and concentrated instruction during the whole of one University term through a planned course of lectures and practical training in the orthopaedic out-patient department of the General Hospital. Further attendance at the out-patient clinics is voluntary, but this privilege is taken advantage of by a considerable proportion of the students. As in Johannesburg undergraduate instruction in orthopaedic surgery is adequate including out-patient ward and operative teaching combined with training in orthopaedic pathology. Facilities for full post-graduate training in orthopaedic surgery are available in Cape Town but at present it is considered that the number of trained orthopaedic surgeons is sufficient for the posts available in the Union.

**Pretoria, Durban, and Port Elizabeth** now have active orthopaedic centres under Mr du Toit, Mr Allen and Mr Muster. The Orthopaedic Surgeons Group of the Union of South Africa which is an active clinical body, meets in the different centres twice each year.

**Poliomyelitis in South Africa**—We learn with regret that South Africa is in the midst of a severe epidemic of poliomyelitis. Since January of this year 1062 cases have been reported (Europeans 784 non-Europeans 278). Cases have been reported in Johannesburg 535, the Transvaal Province 832, Cape 82, Orange Free State 56 and Natal 96. The epidemic is notable for the high proportion of adult cases. The Orthopaedic Section of the Thirty-sixth South African Medical Congress will meet in Pretoria in July 1948.

## COLONIES OF EAST AND WEST AFRICA

**Panel of Medical Consultants for the Colonies**—The Secretary of State for the Colonies has recently appointed a panel of medical visitors to East and West Africa (*Times* March 8, 1948). The scheme was proposed by Professor H. J. Seddon, Nuffield Professor of Orthopaedics at Oxford, and the late Dr W. H. Kauntze, Medical Adviser to the Secretary of State. The Nuffield Foundation has generously undertaken to finance the scheme during an experimental period of six years.

The Colonial Medical Service labours under several peculiar difficulties, one of which is the discouragement which arises from the isolation of many of its members. There is lack of professional companionship and of contact with leaders in the various fields of medical activity. During the war medical consultants in the Army Commands of East and West Africa, mostly men from British teaching hospitals and medical schools, were strikingly successful in stimulating the enthusiasm of junior colleagues, many of whom were stationed in remote places. The Colonial Office has followed this precedent in undertaking a development of Colonial welfare which promises to be of great significance.

Specialists from a panel of eighteen will each visit Africa twice in the next six years. If the experiment is successful it may be extended to other parts of the Colonial Empire. The consultants will go out with the blessing of the Secretary of State, but they will also be under the aegis of the Nuffield Foundation and will have no departmental or official status. It is believed that men in the field will discuss their difficulties with a freedom which would probably have been difficult or impossible if the consultants had been government servants. The various specialists, most of whom are well-known teachers, have been chosen for their particular knowledge of the special problems of colonial medicine such as tropical diseases, tuberculosis, venereal disease and child health. They will be able to give valuable advice to administrators, public health workers and clinicians. But even more the visiting specialists have been chosen for their qualities of congeniality and friendliness which will make them acceptable guests in the bungalows of men who work in solitude.



## NEW ZEALAND

ANNUAL MEETING OF THE ROYAL AUSTRALASIAN COLLEGE  
OF SURGEONS, 1948

The Annual Meeting of the Royal Australasian College of Surgeons was held in Dunedin, New Zealand on January 28, 1948

**Bilateral Rupture of the Long Tendon of the Biceps**—*Mr Kenneth Christie* reviewed the literature and referred to the analysis of Gilcreest which showed that rupture of the biceps tendon involved the long head in 65 per cent of cases the short head in 26 per cent both long and short heads in 7 per cent and the lower common tendon in 4 per cent Only in 5 per cent of cases was the rupture bilateral Senile degeneration due to diminished blood supply together with attrition due to the peculiar course of the long tendon over the head of the humerus which was often the site of arthritis with marginal osteophytes were the predisposing causes The exciting cause was flexion of the elbow against powerful resistance

In long-standing ruptures and in old age operation was often not indicated, but in other cases early operation was advised Mr Christie demonstrated the results of passing the biceps tendon through the tendon of insertion of the pectoralis major tendon looping it round and suturing it to itself After operation the limb was immobilised in the flexed position for three weeks Return to work could be expected in eight to twelve weeks The prognosis was good Even in comparatively late cases it was possible to regain almost normal muscle power Medico legal aspects were discussed

## NORWAY

**Decoration of Dr Smith-Petersen**—On December 6 1947 Dr M N Smith-Petersen was decorated by the King of Norway with the Grand Cross of the Royal Order of St Olave—the highest Norwegian award that it is possible to confer

**Lectures in Norway by Mr I Lawson Dick**—During the last few months British Medical Association Lectures have been given by distinguished British physicians and surgeons in Czechoslovakia Denmark Spain and the Netherlands Mr Lawson Dick took the place of Sir Reginald Watson-Jones in Norway and lectured on orthopaedic surgery After his return he wrote 'The welcome could not have been more cordial National feeling in Norway is very strong and they have a high regard and warm affection for Britain Both in Bergen and in Oslo we had marathon evenings with two lectures one straight after the other but the audiences were so responsive that it was no effort The long stay hospitals for tuberculosis and orthopaedics are very fine The Martini Høusén Hospital near Oslo, and the Kysthospitalet i Hagevik which is on the coast about fifteen miles south of Bergen are lovely buildings, magnificently situated in superb surroundings Medicine in Norway bears the mark of long isolation Their fracture treatment shows much more of the influence of Böhler than is now seen in Britain But some of their work is excellent The imprint of Dr Smith-Petersen's teaching is everywhere recognisable Specialisation is not yet completely developed but they are taking active steps to introduce it Five years of occupation did not break the Norwegian courage Nearly all the doctors had been in concentration camps The Secretary of the Norwegian Medical Association had been interned for five years because his colleagues would not subscribe to the new German controlled Medical Association My host in Strønger had tears in his eyes when he told me how he saw the first British paratroops march down the hill into the town I shall never forget my visit which was made wonderfully enjoyable by boundless Norwegian hospitality'

## SPAIN

In February 1948, the Spanish Ministry of Labour approved the establishment of a School of Industrial Medicine, administered by the Spanish Institute of Medicine and Industrial Safety, and attached to the Central University of Madrid as a post-graduate school One of the objects is the training of specialists in orthopaedic and traumatic surgery A University degree in these subjects will be demanded of those filling orthopaedic vacancies in the National Insurance Scheme and in the Insurance Companies concerned in industrial medicine Research will be carried out over a wide field of industrial medicine We welcome this practical understanding of the important part which orthopaedics has to play in industrial medicine

## FIRST INTERNATIONAL POLIOMYELITIS CONFERENCE—NEW YORK

The first world conference on infantile paralysis is to be held in New York on July 12-17 1948 It is sponsored by the National Foundation for Infantile Paralysis of the United States There will be representatives from China, Sweden, France, Argentine Brazil, Great Britain, and other countries Professor H J Seddon will show a film prepared in Oxford

# Book Reviews

**SURGICAL TREATMENT OF THE MOTOR SKELETAL SYSTEM** Edited by Frederic W BANCROFT A.B. M.D. F.A.C.S. (Supervising Editor) and Clay Ray MURRAY M.D. F.A.C.S. (Associate Editor) 10x6½ in Pp xiv+1254 with 1063 figures Index Two volumes 1946 London J. B. Lippincott Company Price £6

The field of knowledge in every branch of surgery is becoming so expanded that already it is almost impossible for a single author to accomplish the task of writing a comprehensive volume. Inevitably the text book of multiple authorship has come to stay. The system has certain disadvantages the chief of which is that the quality of the various contributions both in substance and in style is seldom consistently maintained throughout the book. Another common failing arises from the tendency among some authors—possibly invited to contribute because of original work previously published—to put forward their own particular methods to the exclusion of others, often equally effective and more generally recognised. This book accords with this general statement.

In conception it is admirable—it sets out to tell the surgeon what to do when to do it and how to do it in relation to the whole field of surgery of the motor skeletal system. In large measure the editors and forty-one contributors have succeeded in this aim.

The first volume is devoted mainly to the management of deformities, infections, tumours and other non-traumatic orthopaedic affections. The second volume deals with the treatment of injuries and includes an admirable discussion on the present position of chemotherapy and a chapter on war surgery.

With few exceptions the various subjects are covered fully and in an up to date manner. Among others the sections on the general principles of fracture treatment and on the management of scoliosis are particularly valuable though the latter is made difficult to read by the author's complicated style. From the chapter on tuberculosis of bones and joints the reader inevitably gains the impression, perhaps unintended, that a short cut to cure can frequently be achieved by surgical treatment. This is a fallacy which has been recognised in this country since the days of H. O. Thomas and Sir Robert Jones.

In the section dealing with congenital talipes equinovarus it is a little surprising to find that treatment by Denis Browne splints receives no mention. Surely too it is illogical to discuss the surgical treatment of this deformity before considering non-operative forms of treatment. Similarly one is amazed to find that in describing the technique of insertion of a three flanged nail for fractures of the neck of the femur the contributor makes no mention of the use of a preliminary guide wire and cannulated nail. This omission is rectified by the editor in one of the many interpolations he has made throughout the book whenever he has felt that additional comment was required for completeness.

The production, as is usual with Lippincott publications, is excellent though there are minor points of criticism: the reproduction of radiographs is in many instances imperfect, misprints are not infrequent and the legends of two illustrations (Figs 162 and 163) are reversed. It is a pity too that there is no more clear indication of the number of the volume on the outside cover—the two volumes are distinguishable only by a single star on one and a double star on the other. The inclusion of a complete index of the whole work in each volume is a particularly welcome feature which might be more widely adopted in multi-volume text-books.

This work cannot fail to achieve a wide reputation since it fills a long-felt want for a comprehensive and up-to-date guide to the treatment of orthopaedic conditions. Orthopaedic surgeons throughout the world will regret the tragic death since the book was published of the Associate Editor Clay Ray Murray. His virile and receptive mind would have welcomed criticism and he would have done much to improve subsequent editions of this already invaluable book.—H. OSMOND-CLARKE

**THE CAUSATION AND TREATMENT OF DELAYED UNION IN FRACTURES OF THE LONG BONE** By Kenneth W. STARR O.B.E. M.S. F.R.C.S. F.A.C.S. F.R.A.C.S. Surgeon Sydney Military Hospital Visiting Surgeon Concord Military Hospital 9½x6½ in Pp xiv+215 with 106 figures 3 coloured plates and 4 tables Index 1947 London Butterworth & Co. Ltd Price £2 2/-

This book, which is a Jacksonian Prize Essay, is divided into three parts: the first deals with the structure of bone, the chemistry of bone, the cycle of bone reconstruction and the relationship between structure and function in bone morphology. The second part is concerned with the healing of fractures and the third with the etiology and treatment of delayed union. Fifty illustrative cases are reported briefly in one of the appendices. Consequently the problems of bone growth, bone repair and its complications are considered from many aspects.

In his introduction the author makes a somewhat naive acknowledgement of his felony in borrowing

without shame from the scientific riches stored in the bibliography." The text abounds with references but the reader is sometimes puzzled to know which part is the borrowed riches and which the author's own opinion. The bibliography contains 615 references but omits any mention of Hertz's work on Vitamin C. The proven deleterious effect of lack of Vitamin C in the healing of fractures is not considered in the text. The book is profusely illustrated. The micro photographs and radiographs are excellently produced but many of the tables and diagrams for example Fig 63, are reduced to such a degree that a magnifying glass may be required to read them. The text contains a wealth of information but critical appraisement and correlation of the information is somewhat lacking.—Robert I. STIRLING

**BRACHIAL PLEXUS LOCAL ANAESTHESIA** By R. R. MACINTOSH, M.A., M.D., F.R.C.S. D.A., Nuffield Professor of Anaesthetics, University of Oxford, William W. MUSHIN, M.B. B.S. D.A. First Assistant Nuffield Department of Anaesthetics. 7½ x 5 in. Pp 55 with 33 figures. 1944. Oxford Blackwell Scientific Publications Ltd. Price 10/6.

The first edition of this small monograph was published in 1944. In the second edition which has now appeared there have been no material additions. The striking features of the book are the excellence of the illustrations and the clarity of presentation.

A short history of the various methods of producing brachial plexus block is followed by a discussion on its indications and advantages. The section dealing with the anatomy of the plexus is profusely illustrated in a way which emphasises the important topographical relations of the brachial plexus in the region of the first rib. Fig 8 is an example. The actual technique is also illustrated admirably and made abundantly clear. The method described is with minor modifications essentially that of Patrick which is undoubtedly the most reliable (PATRICK J. The Technique of Brachial Plexus Block Anaesthesia. British Journal of Surgery 1940 27, 734).

References are made to premedication and local anaesthetic solutions and the book concludes with a brief description of the anatomy of the stellate ganglion and the signs of stellate ganglion paralysis.—J. D. EBSWORTH



FIG 8 Page 18

**THE INTERNAL FIXATION OF FRACTURES** By Charles Scott VENABLE M.D., M.S. F.A.C.S. and Walter Goodloe STUCK M.D., M.S., F.A.C.S. 10 x 6½ in. Pp vi+237 with 84 figures. Index. 1947. Oxford Blackwell Scientific Publications Ltd.

Less than fifty years ago the internal fixation of fractures was so unreliable and dangerous a method of treatment that it was condemned by all but a few of the more adventurous pioneers of surgery. Later the method achieved a considerable vogue and in the hands of a few skilled surgeons was attended by satisfactory results in a fair proportion of cases. In general however the results continued to be indifferent and it was not until the introduction of metals which are relatively inert in the body that consistently satisfactory results began to be obtained. With the development of inert metals to their present state the principle of internal fixation of fractures has now achieved an established place in orthopaedic surgery and it is generally regarded as a safe and reliable procedure provided that certain conditions are observed. Nevertheless the fact that cases are not infrequently seen even to day where the choice of method or of materials has been unfortunate emphasises the necessity for every surgeon who undertakes the treatment of fractures to make himself thoroughly familiar with recent developments in this field and this book will serve a useful function in bringing together under one cover essential features of the many contributions on internal fixation.

The book is arranged in two main sections. In the first part the authors sketch historical outlines of the development of the use of metals for internal fixation leading up to the introduction of the relatively inert stainless steels and of vitallium. These and other metals are described in some detail, their relative advantages and disadvantages are discussed, and the technique of their application is considered. An important point which is wisely stressed is that two metals of different composition even though each is

individually inert may nevertheless set up undesirable electrical reactions if used together in the same operation area, all metal parts used in a given area must be identical in composition if this risk is to be avoided.

The second part of the book deals with the application of the principles of internal fixation to various individual fractures of the upper and lower limbs. While the approach is reasonable and the exposition clear this section does not appear to fill any significant gap in surgical literature—the survey is too limited in scope to be of use as a comprehensive treatise on fractures—and the special problems of internal fixation which are discussed are for the most part covered fully in modern text-books on the subject. Nevertheless there are some stimulating chapters. In particular the problem of fractures of the neck and trochanteric region of the femur is discussed very adequately. There will be some however who will not agree that vascular changes in the femoral head can be avoided by early and adequate reduction and fixation. Others—they may be fewer in number—will require further evidence before they are convinced that internal fixation is the treatment of choice for the trochanteric type of fracture or that the mortality in this type is in fact less with operative treatment than with the best conservative treatment in a comparable series of cases.

It is surprising that there is no description of the use of the long intra-medullary nail. This method of internal fixation is widely accepted as having a place in fracture treatment particularly for certain fractures of the shaft of the femur and some reference to it would have been expected in a work of this kind. Another minor criticism is that the authors advocate or at least condone the use of the heavy rubber tube type of tourniquet. Nevertheless in general the principles advocated are sound and the judgment is well balanced. The book should have considerable appeal particularly to those who are in the course of orthopaedic training and to those who have special interest in the mechanical aspects of fracture surgery.—J. C. ADAMS

**DISEASES OF THE JOINTS AND RHEUMATISM** By Kenneth STONE D.M. M.R.C.P. Honorary Physician British Red Cross Society Clinic for Rheumatism Peto Place London.  $9\frac{1}{4} \times 6$  in. Pp. v+362 with 58 figures. Index. 1947. London Heinemann (Medical Books) Ltd. Price 30/-

This book is intended to remedy defects in the teaching of rheumatology which the author would prefer to call Orthopaedic Medicine. It is no longer advisable to stress any cleavage between medicine and surgery particularly in orthopaedics. One feels sure that this is not Dr Stone's intention nevertheless co-operation with an orthopaedic colleague would have produced a more comprehensive and accurate review. Having made this complaint one must add that there is much to commend in this book. Dr Stone does not confine himself to a factual discussion there are many pleasant excursions into the fields of medical philosophy and history which will stimulate the reader to think.

The first part of the book is devoted to a discussion of general principles and the pathology of arthritis. Very rightly the work of Hilton on physiological rest is emphasised nevertheless too little space is devoted to the important matter of physiological splintage. The next six chapters discuss diseases of the joints upon a regional basis. The large problem of the osteoarthritic hip is given very brief discussion. Surgery still plays an important part in treatment and yet the matter is dismissed in eleven or twelve lines. No mention is made of arthrodesis let alone arthroplasty. The surprising statement is made that as a rule surgical treatment will never be considered for a patient over fifty-five years of age.

The final section comprising five chapters is devoted mainly to the subject of muscular rheumatism and fibrositis. Dr Stone discusses in some detail the anatomy and physiology of the autonomic nervous system and explores the fascinating hypothesis of Eppinger and Hess on the subject of vagotonia. He regards pronounced parasympathetic stimulation as an explanation of many of the phenomena of muscular rheumatism. The book concludes with a discussion of lumbago and sciatica. On the subject of sciatic scoliosis we read that text-books still affirm that the erector spinae are in a state of spasm. But a spasm of the erector spinae would *hyperextend* the lumbar spine and this one never sees. The problem of spinal muscle spasm in these cases is a very real one and deserves fuller and more accurate statement. A great deal of space is devoted to the theories of Cotugno (1764) on nervous sciatica—a discussion which tends to confuse rather than illumine the mind of the reader. In the first attack of sciatica due to intervertebral disc lesions rest in bed is recommended but if weeks elapse with no sign of abatement and if to be up and about is imperative the only recourse is to immobilise the spine in plaster—a method which in some instances appears to be successful. Thus is dismissed the conservative orthopaedic treatment of this common disability. These occasional deficiencies in the details of orthopaedic practice are unfortunate for the book contains so much that is good for the general practitioner and senior student.—Norman CAPENER

EXCERPTA MEDICA Edited by M W WOERDEMAN, Professor of Anatomy and Embryology University of Amsterdam A P H A DE KLEYN Professor of Oto-rhino laryngology University of Amsterdam and W P C ZEEMAN Professor of Ophthalmology University of Amsterdam In fifteen sections Section IX SURGERY 9 $\frac{3}{4}$ ×6 $\frac{1}{2}$  in Pp 120 Index of authors 1947 Edinburgh E & S Livingstone Ltd Price £9 6/- for annual volume of Section IX Paper cover

This work is succinctly described as "A Complete Monthly Abstracting Service of the World Medical Literature comprising fifteen sections and covering the whole field of theoretical and clinical medicine". The abstracts are in English are made by experts, and are signed. In addition to current articles the more important ones going back to 1940 which have not been readily available on account of the war will be included in the earlier numbers. Each volume will have a subject and authors index. The abstracts in the Surgery section are arranged under seventeen headings of which number 13 is devoted to Orthopaedic Surgery which conveniently follows Vascular Surgery and precedes Traumatic Surgery. Those interested in the territorial claims of the specialties will note that Orthopaedic Surgery here comprises Physical Medicine Fractures Dislocations Bones Joints Muscles, Tendons Bursae and Amputations. Traumatic Surgery is confined to Herinal Injuries Wounds, Shock and Transfusion. Other headings of interest to the orthopaedic surgeon are 15 and 16 on Military and Experimental Surgery respectively and 1 to 5 on Anaesthesia Pre and Post-operative Therapy Surgical Technique Surgical Infections and Tumours. The abstracts are very well done and we should be most grateful to our Dutch friends for this important contribution. It is salutary also to remember the large part which the American nation has played towards making English the scientific language of the world.—H JACKSON BURROWS

### CONTRIBUTORS—MAY 1948

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# The Journal of Bone and Joint Surgery

## VISIT OF THE NUFFIELD AND TRAVELLING FELLOWS IN ORTHOPAEDIC SURGERY TO THE UNITED STATES AND CANADA

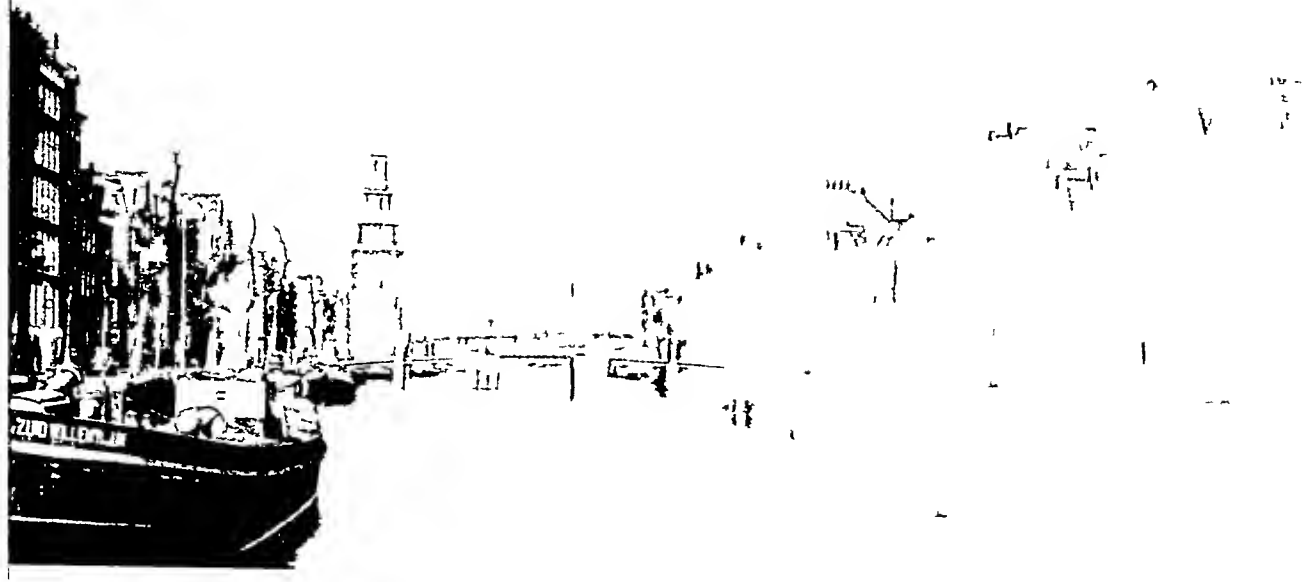
It has been my special privilege to be allowed to read the personal diaries of several of the Nuffield and Travelling Fellows who recently enjoyed the hospitality of their American and Canadian hosts. I must say that in browsing through these pages, and reading an account of the Ball which was held during the combined meeting of the American, British, and



NUFFIELD AND TRAVELLING FELLOWS IN ORTHOPAEDIC SURGERY

James Patrick James Ellis John Charnley Derek Strange Pip Newman Freddie  
Durbin John Adams Miss Marion Pearson John Fairbank Ian Smillie James Wishart  
Cecil Langton Edgar Somerville

Canadian Orthopaedic Associations in Quebec, I was electrified to learn that "W-J was on the path of the Welsh girl," which goes to show how unwise it is for any man to read another man's diary! But it is evident that the truth, or at least that part of the truth which at the time was apparent to the mind of the writer, is recorded in these diaries in plain and unvarnished terms. That the observations were indeed plain cannot be doubted when we read "Have just seen some awful fracture treatment, they seem to operate on most everything and fill it up with hardware." But, lest it be thought that the author



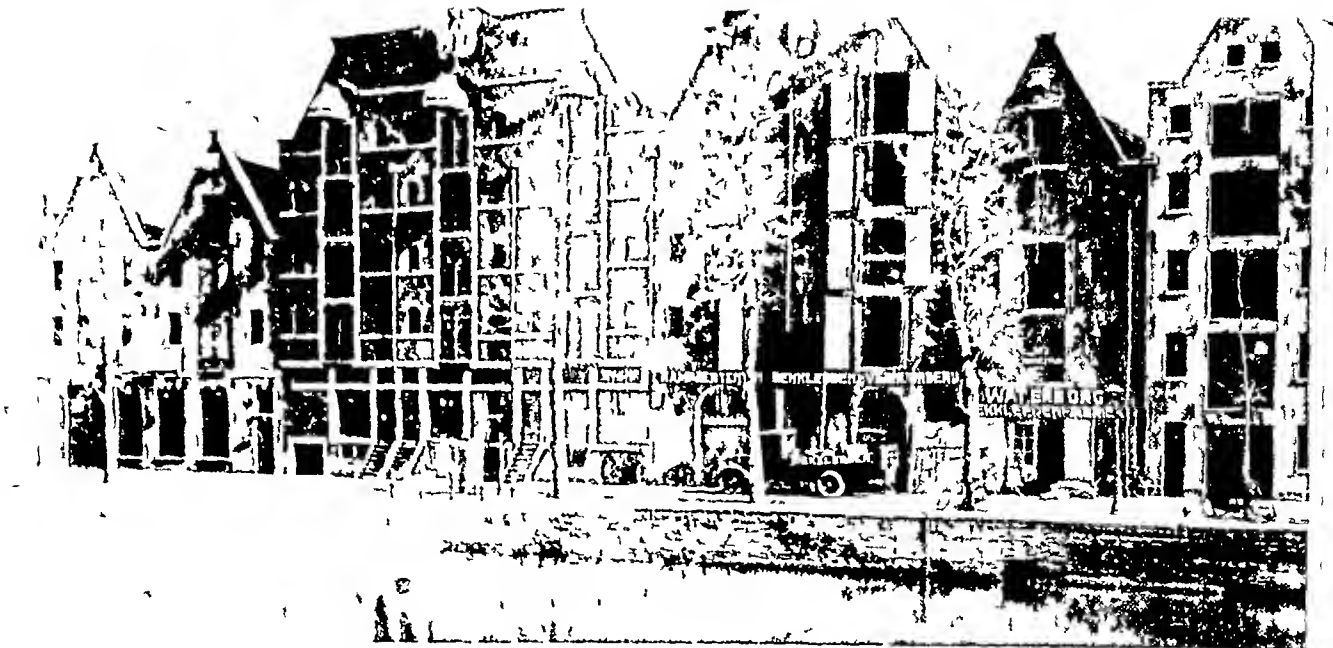
was prejudiced, let us turn his pages and read an account of another day "This was the best operative performance I have ever seen—quite faultless and most impressive"

We must start at the beginning. One fellow, shortly after embarking in the *Queen Elizabeth*, wrote "Got on board and felt a little homesick. Knew that I would rather much be rustivating in my country garden than being whirled round at break-neck speed in the United States—but within a week the same young surgeon was writing "This trip is terrific. Enjoying it immensely. Getting a picture of American surgery which normally would take months to acquire. It will be something to look back on for years to come, and against which to weigh this and that"

There seems to be general agreement that "the pace was terrific." One wrote "We need all the rest we can get—we shall be pretty fagged by the end of this show." In the words of another "The organisation has been tip-top—it had to be, to keep up with the programme." Yet another reflects the spirit of urgency "Bed at two—exhausted. Up again at three. One hour sleep. Driven one hundred miles to Niagara Falls. Back and breakfasted by nine a.m. to start of our programme. Well worth the trouble—it was astounding—the roar and sea of power was tremendous." One of the visitors, after returning to England wrote "It is quite a change getting back to hard work—and in many ways quite restful"

There can be no doubt that deep impressions were made by the "great phantom of Manhattan," the George Washington Bridge, the Harvard Club "looking four hundred years old but really built in 1913," the Boston Braves playing St Louis, the "lovely dream of a house in Philadelphia," the Lincoln Memorial, the White House, the Sunday breakfast with one hundred guests, the citadel of Quebec "where D day was fixed," the reaches of the St Lawrence, the French-Canadian farms, the Royal Mounted police, the new-born babies in plastic cots and perspex incubators, and—surprising as it may seem to our American friends—"the goldfinches almost all golden yellow," the "butterfly called Camberwell Beauty which is rare in England," the seagulls on Lake Ontario, and the cotton-tail rabbit "with a tail just like a lump of cotton, bigger than ours though otherwise much the same"

But the profound impression which remains, and will remain throughout the lifetime of these thirteen travelling fellows, is that which was inspired by the visit to thirty-four hospitals in thirteen cities in forty-two days, during which time they heard two hundred and fifty scientific papers. It is perhaps not surprising that two of them, when asked to record their impressions in this number of the *Journal*, claimed indulgence for the reason that it was difficult to orientate themselves to so vast a symposium within so short a time. Of their new friends and colleagues in the United States and Canada they say "With some we were in agreement, with some we were not, but all were stimulating." The final entry



in the diary of the surgeon whose first instinct was to regret his fate in being whirled around the United States is recorded in these words

'It is really something quite unique

that we should have everything served up on a dish like this We hope that a similar group of young American and Canadian orthopaedic Surgeons will be able to return the visit This is the start of something big"

EDITOR

The International Orthopaedic Society will meet in Amsterdam in September 1946 This photograph is reproduced from *Amsterdams Bouwkunst en Stadsschoon 1306-1942* (published by C V Allert de Lange) by courtesy of my friend F A Warners the architect of Amsterdam who in former years thrilled and inspired me with the joys of this wonderful city of old buildings and waterways—EDITOR

#### SOCIÉTÉ INTERNATIONALE DE CHIRURGIE ORTHOPÉDIQUE ET DE TRAUMATOLOGIE

In 1929 the late Fred Albee of New York applied his energy to the task of persuading European colleagues that the time had arrived for the creation of an International Society of Orthopaedic Surgery It was necessary for him to convince two people—Sir Robert Jones and Professor Vittorio Putti The idea did not at first appeal to members of the British Orthopaedic Association who suggested the alternative proposal of an International Council which would maintain liaison between existing national orthopaedic societies It soon became clear that the orthopaedic surgeons of European countries would be satisfied with nothing less than a permanent society, organised on the lines of the International Society of Surgery which had its headquarters in Brussels Accordingly, a meeting was held in Paris in October 1929, at which the new Society was launched with the goodwill of delegates from thirteen countries The British delegate on this occasion was Thomas Fairbank By unanimous vote, Robert Jones was chosen as first President, with Professor Putti and Professor Gocht of Berlin as Vice-Presidents Professor Maffei and Dr Delchef of Brussels were elected Treasurer and Secretary It was decided that the Society should meet every three years, and that membership should be limited to one hundred

The first Congress was held in Paris in October 1930 Sir Robert Jones gave his presidential address on "The Domain of Orthopaedic Surgery" Two subjects were discussed 'The treatment of congenital dislocation of the hip joint after the age of fifteen years', and "Injuries of the wrist joint", each subject being introduced by "rapporteurs" who were chosen in advance

The second Congress was held in London in July 1933 By then the Society had lost its first President Sir Robert was succeeded by Dr Murk-Jansen of Leiden, superb poly-linguist



and close friend of orthopaedic surgeons in many countries. The London Congress, attended by more than one hundred members and visitors, was an outstanding success. Professor Nove-Josserand of Lyons presided over its deliberations with dignity and charm. At a reception at the Royal College of Surgeons of England the Honorary Fellowship of the College was conferred upon him. Professor Putti was chosen as President of the next Congress to be held in Bologna and Rome in September 1936. It will be noted that the Society has always had two Presidents—a President of the Society, a more permanent officer who presides over the International Committee meetings, and a President for each Congress.

The third Congress was held in Bologna and Rome in September 1936. It will long be remembered for its brilliant setting under the presidency of Professor Putti who was acclaimed as the intellectual leader of international orthopaedics. The Society had then lost two of its great founders, for Mink-Jansen died in 1935. He was succeeded as President of the Society by Professor Louis Ombredanne of Paris, who has conducted the affairs of the Society with wisdom and distinction during the past twelve years. At the Bologna meeting the title was changed to '*Société Internationale de Chirurgie Orthopédique et de Traumatologie*,' despite opposition from German members who were still suffering from the domination of general surgeons, and had difficulty in accepting the inclusion of traumatic surgery. Preliminary arrangements were made for the fourth Congress to be held in Berlin in September 1939 under the presidency of Professor Hermann Gocht, with Dr Fred H. Albee and Professor Patrik Haglund of Stockholm as Vice-Presidents. By July 1939 the programme was in the hands of all members, and most "rapports" on the main subjects had been printed and distributed. Many members had made travel arrangements. Professor Georg Hohmann of Frankfurt was in London in July with many of his colleagues, attending an international cripples' conference, and he assured the late Mr Rowley Bristow and this writer that no international incident would prevent the Congress being held. We had no reason to doubt this belief. But the meeting was cancelled.

After the liberation of Belgium and France Professor Ombredanne and Dr Delchef got into touch with national delegates of Allied and friendly nations. An International Committee meeting was held in January 1946, and in October 1946 the Society was "re-born" at a Scientific Reunion in Brussels.

The fourth Congress, the first post-war Congress as already announced in this Journal, will take place in Amsterdam between September 13 and 18.

HARRY PLATT

# INFECTIONS OF THE HAND

J B LOUDON, J D MINIH RO, AND J C SCOTT, OXFORD, ENGLAND

*From the Accident Service, Radcliffe Infirmary Oxford (Director—J C Scott)\**

From January 1945 to December 1946, 723 patients with infections of the hand attended the Casualty Department of the Radcliffe Infirmary, Oxford. This represented a loss of 104,112 man-hours, or the equivalent of five months' work for one hundred men. That these infections account for serious clinical problems is generally recognised, but the number of man-hours which is lost is not appreciated fully.

We have been impressed by the large number of hands which despite treatment were damaged beyond repair, both functionally and cosmetically. This was sometimes due to neglect in treatment, but in other cases it was the inevitable result even after the early application of all methods in current use. These patients were the most regular attenders at the Casualty Department. Their dressings required changing, sometimes more than once daily. Frequent dressings were not only painful, but they often led to secondary infection of the wound. Almost invariably they involved many hours of travelling and waiting, and much expense. This paper is presented with the object of stressing the economic importance of infections of the hand, of reiterating the necessity for early treatment, and of indicating the results of a method of treatment which has been in use for the last six months. The main departure from accepted principles has been that instead of performing incision and drainage, excision and suture was carried out wherever possible.

## CLASSIFICATION OF CASES

- |                |   |
|----------------|---|
| <b>Fingers</b> | 1) Pulp infection— <i>a</i> ) distal, <i>b</i> ) middle, <i>c</i> ) proximal  |
|                | 2) Paronychia   |
|                | 3) Dorsal space infection— <i>a</i> ) middle, <i>b</i> ) proximal             |
| <b>Hand</b>    | 4) Distal palmar pulp infection ("web space infection")                       |
|                | 5) Thenar space infection   |
|                | 6) Mid-palmar space infection   |
|                | 7) Hypothenar space infection   |
|                | 8) Dorsal space infection— <i>a</i> ) subcutaneous, <i>b</i> ) subaponeurotic |
|                | 9) Tendon sheath infection  |

No case of infection of the radial or ulnar bursa was seen in six months.

Based on the most constant symptoms and signs, and for ease of description, we have divided all finger and hand infections into four degrees.

First degree —Throbbing and tenderness,

Second degree—More marked pain, redness, swelling and heat, tenderness and fluctuation,

Third degree —Pain, redness, swelling, fluctuation, heat, tenderness, and devitalised skin,

Fourth degree—"The discharging hand", pain not so marked but sinus present.

With the third and fourth degrees there may also be clinical or radiographic evidence of destruction of deep tissues.

**Etiology**—In half the series of sixty-nine cases, there was no history of injury. When there was no trauma, minor cut, puncture wound, or blister, it seems probable that the infection was often blood-borne, particularly in distal pulp infection of the fingers. The incidence does not appear to vary with the time of year, nor with the type of peripheral circulation, but it is clearly related to the occupation of the patient. Housewives were most often affected (Table I).

**Bacteriology**—A pure growth of staphylococcus aureus was cultured in 87 per cent of the cases. The remaining ones grew staphylococcus aureus and B-haemolytic streptococcus (6.5 per cent), or they were sterile (6.5 per cent). In the very large majority the organisms were sensitive to penicillin.

\* Received for publication February 14 1948

# PATHOLOGY

The initial lesion in infections of the hand consists of a group of organisms surrounded by an area of reaction. As in all infections, subsequent events depend upon the result of a conflict between the general and local resistance, and upon the type, virulence, and number of the invading organisms.

In fascial space infections the lesion consists of three distinct zones: a) a central zone with pus under tension—the result of death of cells at the site of entry of the invading organisms, b) a middle zone of tissues not yet transformed into pus but already undergoing necrosis, c) a peripheral zone where the tissues are viable, but are subjected to considerable tension due to increased blood flow and oedema, surrounded by normal tissue (Fig. 1).

Progressive tissue necrosis, with increased extra-vascular fluid in the immediate vicinity, leads to increasing tension which interferes seriously with blood supply and local resistance, thereby establishing a vicious circle. The resulting spread of tissue necrosis is irregular, and is governed largely by the power of resistance of the tissues and by the local anatomical arrangements.

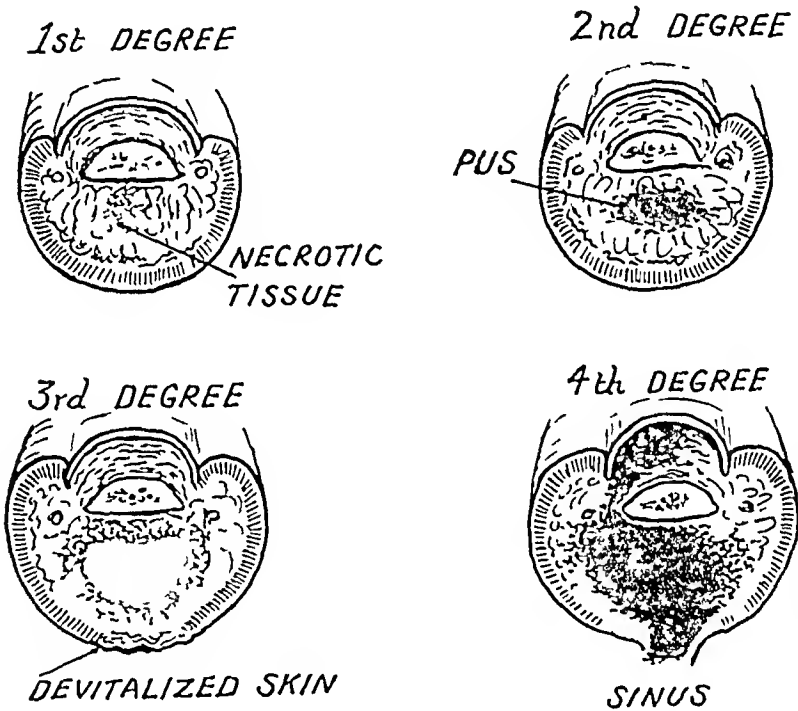


FIG. 1  
Pulp Space Infection

Sometimes the symptoms are more pronounced at a distance from the initial lesion, as in the case of distal palmar pulp infections. We have found that in this type the initial lesion is always in the distal palmar pulp, over the base of the proximal phalanx, the web space being infected secondarily (see Case history 3). The signs are more marked in the web space by reason of the laxity of tissues.

In tendon sheaths, infection has invariably spread throughout the length of the sheath by the time that a diagnosis is made. Where infection has spread from neighbouring tissues, or where it is due to a wound, the severity of the destructive process may be much more pronounced at the site of original infection than in the rest of the sheath, but necrosis may occur at a point distant from the initial focus of infection, where overlying structures compress the swollen and oedematous tendon and sheath. The pathology of tendon sheath infections will be described later in more detail.

### TREATMENT

**Aims of treatment**—The aims of treatment are two-fold 1) *Surgical*—a) to secure routine early and adequate surgical intervention, with elimination of the methods of blind surgery, b) to avoid spread of infection, and secondary infection, consequent upon the use of drains and the methods of frequent dressing, c) to secure first-intention healing, 2) *Economic*—by these methods to minimise permanent loss of function, reduce loss of man-hours, conserve hospital facilities, and save unnecessary cost to the community

**Method of treatment**—The principles of treatment are based upon 1) evacuation of pus, and 2) excision of necrotic tissues When using an adequate exposure with a bloodless field the necrotic area can be seen clearly Excision takes the place of the usual process by which dead tissues are eliminated by discharge Healing is thereby accelerated Moreover, the best possible conditions are provided for control of residual infection by the striking and immediate improvement in local blood supply after relief of tension

**Skin cover**—Immediate or early skin cover is the best defence against secondary infection, moreover it minimises the amount of scarring Primary suture is therefore carried out whenever possible, the tissues being protected thereafter from the trauma of movement by immobilisation in plaster When immediate skin cover is not possible, early skin grafting should be used, the principle of infrequent dressing and plaster protection being employed meanwhile because it not only encourages healing but reduces the incidence of secondary infection Early healing is the key to recovery of function Nothing but harm can result from attempts to persuade a patient to move a finger in which there is still infection

### PRE-OPERATIVE TREATMENT

Under ideal conditions, a patient with spreading infection and general reaction should be admitted to hospital Unfortunately, shortage of hospital beds has been such that some patients in this category were necessarily treated as out-patients Those who were admitted, including all patients with cellulitis, had full investigation including urine analysis, differential blood count, blood culture, and estimation of penicillin-sensitivity of the organisms

Before operation the affected part was immobilised by means of a plaster slab, and elevated either by pillows or slings Vitamins A, C, and D were given together with copious fluids and 50,000 units of penicillin three-hourly Reflex vasodilatation was sometimes produced by a heat-cradle over the trunk or lower limbs, but any value that this procedure may have had was outweighed by increased local discomfort

These measures improved the general condition and controlled the spread of infection, but they failed to influence the local lesion, however small, in which death of tissue had already occurred As soon as the general condition was improved, the infection circumscribed, and the blood penicillin level sufficiently high—usually within twenty-four hours of admission—operation was undertaken (see Case histories 68 and 69) About 20 per cent of the patients who were treated as out-patients were given 200,000 units of sodium penicillin three hours before operation, but this did not seem to influence the result and we now operate on out-patients without routine pre-operative treatment

### OPERATIVE TREATMENT

**Theatre preparation**—Strict asepsis, proper instruments, and the aid of an assistant are essential General anaesthesia must be used Pentothal, nitrous oxide, and oxygen are satisfactory anaesthetic agents even for out-patients The instruments which should be available include a pneumatic tourniquet, C T A B for skin preparation, Baird Parker's No 11 and No 15 blades, Poirier's 5-in peritoneal forceps, Michel toothed and plain forceps,

Mayo straight and curved scissors, mosquito forceps, No 19 curved triangular needles, Grade 3N nylon, penicillin powder, calico, plaster of Paris (2-in bandages)

The patient is anaesthetised. The limb is elevated for three minutes (held by the tip of the fingers in order to avoid obstruction of the venous circulation). The tourniquet is inflated quickly to a level above that of the systolic blood pressure. The skin is prepared with cetyl trimethyl ammonium bromide, and acriflavine in spirit.

**Incisions**—The main concern must be not only to gain free exposure of the lesion, but to retain free blood supply to the skin and underlying tissues, and to secure good functional and cosmetic results. These aims can best be achieved by the use of skin flaps turned back.

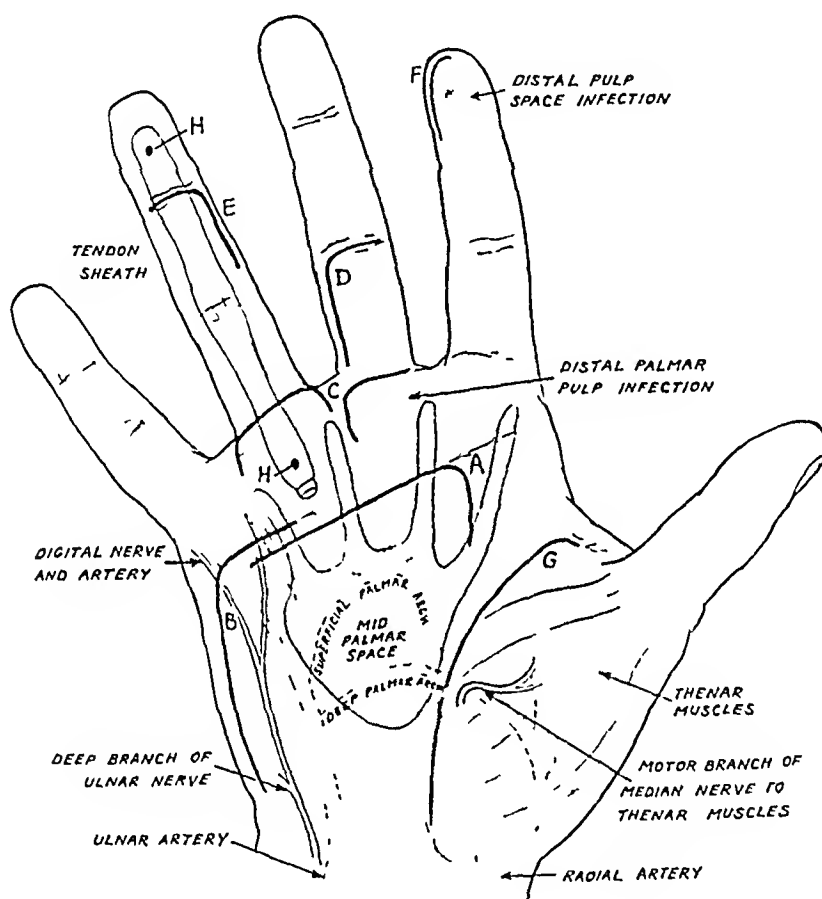


FIG 2

Incisions in relation to underlying structures

from curved incisions placed in the skin creases, parallel to skin creases, or remote from skin creases (Figs 2, 3, 4, and 5). In this way even the most gravely contracted scar never interferes seriously with function. Whenever possible we use incisions in the creases, thus gaining the additional advantage of leaving a scar which is unnoticeable. If there is a sinus, one limb of the incision must pass through it (in or parallel to a crease) and the necrosed edges must be excised conservatively. The ideal is to leave no dead skin and to remove no living skin. The skin must be handled gently, the full depth of subcutaneous tissue being mobilised with it. Poirier's five-inch peritoneal forceps, placed at least a quarter of an inch from the skin edge and kept in position throughout the operation, are ideal. The same incisions are used when there are areas of necrosed skin but skin grafting may subsequently be necessary.

The incision used for thenar space infections is shown in Fig 2G. It is placed parallel to and on the radial side of the adductor skin crease, thus avoiding the danger of opening

the mid-palmar space. It maps out a flap which gives ample exposure of the thenar space. It is possible to prolong the incision proximally or distally to the dorsum of the hand. The motor branch of the median nerve to the thenar muscles, and the superficial branch of the radial artery, can be seen and avoided without difficulty.

Fig 2 shows the incisions used: *a*) for mid-palmar space infection, the palmar fascia being divided on the line of fibres, *b*) for hypotenar space infection, *c*) for distal palmar pulp infection (with this incision we expose both the web space and the primary lesion over the base of the first phalanx, it may be extended as shown), *d* and *e*) for proximal and middle pulp space infection (in middle pulp space infection the transverse limb must be cut with

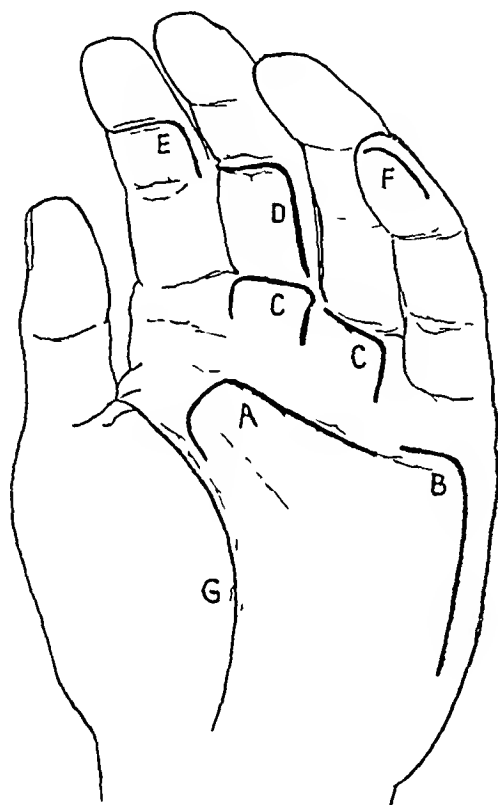


FIG 3

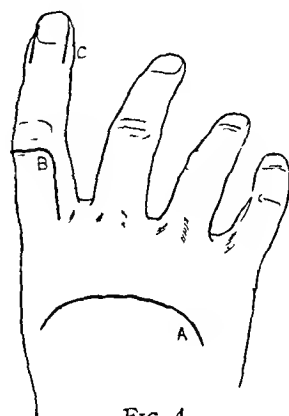


FIG 4

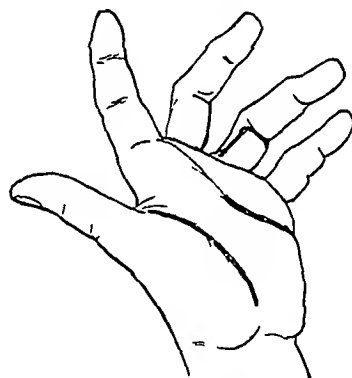


FIG 5

Incisions in relation to skin creases

care owing to proximity of the tendon sheath at the distal flexor crease), *f*) for terminal pulp space infection (this incision gives adequate exposure for excision in almost all cases, and is to be preferred to the "alligator-mouth" incision which is liable to cause delay in healing because of more extensive interference with blood supply to the skin edge). The incisions used for dorsal space infections and paronychia are shown in Fig 4.

**Operative procedure**—The skin flap is lifted and the incisions are prolonged as necessary. The edges are retracted with Poirier's forceps, thus exposing the devitalised tissues. Pus is evacuated. Necrotic tissues, recognised by their colour, are then excised by holding them with toothed Michel forceps and cutting with Mayo curved scissors. If there is infection of bone with sequestrum formation the dead bone is removed. After excision, a thin layer of penicillin powder is insufflated and the flap is sutured without tension with grade 3N nylon in a No 19 triangular curved needle. Thick coverings of penicillin powder are to be avoided because they retard healing.

The tourniquet is released only after suture is complete. Since all the vessels have been seen and avoided, no ligatures are required. A dry calico dressing is applied. The affected part, and no more than the affected part, is then immobilised in plaster. A finger may be immobilised adequately by means of anterior and posterior plaster slabs held lightly in place by a moistened gauze bandage. Vaseline gauze and elastoplast coverings are not advisable because they cause maceration of the skin, permit movement, and do not prevent secondary infection.

### POST-OPERATIVE TREATMENT

Immobilisation is continued until healing has taken place. Elevation is essential. Active exercises of the parts which are not immobilised should be encouraged from the beginning. Oedema is controlled by elevation of the limb and by active exercises. Ambulatory patients are given a sling and it is pointed out to them that the hand must always be kept at a higher level than the elbow. In bed the hand must be slung, or rested on a high pillow. Out-patients are instructed to report at once if symptoms are not relieved by the operation. No patient in this series found it necessary to seek an earlier appointment than had been arranged. All were comfortable and needed only to attend for the twice-daily injections of 200,000 units of sodium penicillin for five days after operation. Three patients were given sulphadiazine and attended only a week afterwards for inspection of the wounds, having had four days of chemotherapy. Three were treated without chemotherapy and healed by primary intention.

Elevation and immobilisation should continue until swelling has disappeared and the wound is healed—usually within ten days. Sutures should not be removed in less than seven days. Gentle use of the digit is encouraged as soon as the wound is healed, even before removal of the sutures. Full movements were regained in all cases by ordinary use of the hand, except in the case of two patients who needed physiotherapy (Cases 62, 65).

Particular care is necessary when there is necrosed skin. As soon as the wound is clean and granulating, skin grafting should be carried out under local anaesthesia. Pinch grafts, taken from the inner surface of the arm, have been used. Immobilisation in plaster was continued for another eight to ten days. Intensive active exercises were then started.

### TENDON SHEATH INFECTIONS

In considering the treatment of tendon sheath infections brief discussion of the etiology and pathology is necessary. In five of our cases the signs could not be correlated with the pathology of tendon sheath infection alone since there was an accompanying lesion, the signs of which were superimposed on those of the sheath infection, giving a combined clinical picture.

There are four main ways in which tendon sheath infection may arise, and there are four degrees of such infection. 1) the infection may be carried to the tendon sheath in the blood stream, 2) there may be lymphatic spread of infection from a neighbouring infection, 3) there may be direct erosion of a sheath underlying a fascial space infection, 4) there may be infection due to direct trauma from a wound, usually over a flexor crease, which may or may not have healed before the sheath infection becomes manifest.

Whatever the etiology, reaction to infection occurs with oedema of the tendon and sheath, and exudate formation within it, the whole sheath being distended with thin, clear fluid. This constitutes a *first degree* infection (see Case 60, Figs 7, 8). At this stage the diagnosis can usually be confirmed only by exposure of the sheath which is best carried out through a short transverse incision over the distal end ("observation incision"). If it is found to be distended with exudate, and to have lost its normal transparency, the sheath is opened and washed out with saline from the proximal end by introducing a needle (Fig 6).

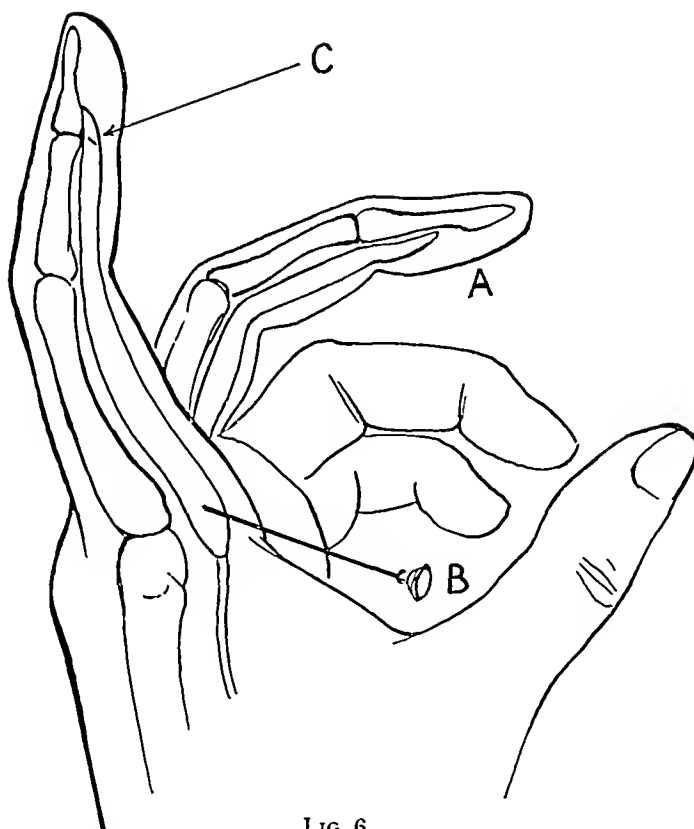


FIG 6

Method of irrigation of first and second degree tendon sheath infections

C—site of observation incision B—needle introduced for irrigation of sheath A—alternative site for irrigation



FIG 7



FIG 8

Case 60 First degree tendon sheath infection showing area of pain and tenderness (Fig 7) and the same hand after treatment by irrigation (Fig 8)



When the needle is in the sheath no resistance is felt to injection, but if difficulty is encountered the proximal end of the sheath can be exposed through a short transverse incision, parallel and distal to the distal palmar crease. Using the same needle, 100,000 units of sodium penicillin in 5 c.c. of distilled water are injected into the sheath and the observation incision is closed. *Second degree* tendon sheath infection is present when the thin, clear fluid is replaced



FIG 9



FIG 10

Case 61 Second degree tendon sheath infection and pulp space infection fourth finger—end result



FIG 11



FIG 12

Case 64 Third degree tendon sheath infection

by pus. At this stage there is pus formation but no visible evidence of extensive damage to the sheath or tendon. The sheath is thick, congested, and oedematous, the tendon is swollen but it still retains a glistening appearance. The usual clinical manifestation is a uniformly swollen digit, tender over the whole of the sheath, and with considerable limitation of movement, particularly of extension. There may, however, be definite signs localised to one part

of the finger when tendon sheath infection arises by lymphatic spread from a pulp space infection in that locality (Case 61, Figs 9, 10). Treatment should be similar to that described for cases in which there are no localising signs. A skin flap is turned over the area where signs are maximal. All necrotic tissues are thoroughly excised. The sheath is exposed, opened and washed out with saline. Penicillin is instilled from both proximal and distal ends till

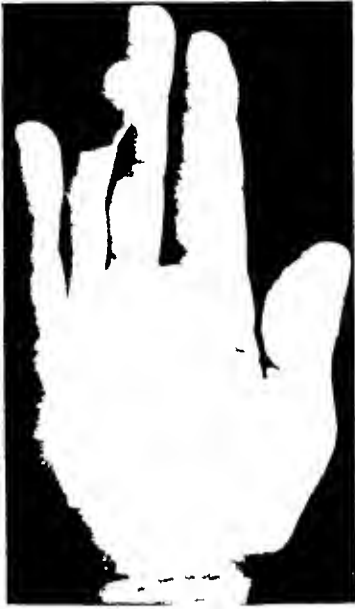


FIG 13



FIG 14



FIG 15

Case 65 Fourth degree tendon sheath infection with sloughing of tendon showing the extent of limitation of extension

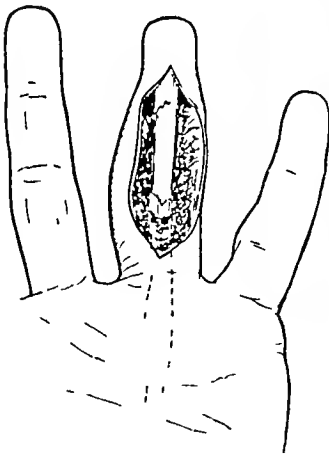


FIG 16



FIG 17



FIG 18

Case 66 Fourth degree tendon sheath infection after operation showing late function

clear fluid is obtained. The skin flap is then sutured in the usual manner. *Third degree* infection is present when part of the sheath has been destroyed, and when there is subcutaneous pus with loss of the normal glistening appearance of the tendon (Case 64, Figs 11, 12). There is redness of the finger, with fluctuation and impaired vitality of skin especially over the palmar surface of one segment. This may be due to fascial space infection caused by direct

spread from an underlying ruptured sheath, or to fascial space abscess which itself caused the sheath infection. In these cases treatment should follow the lines of a second degree infection with localising signs, excision should include the necrotic areas of the sheath. *Fourth degree* tendon sheath infection, when a sinus is present, may result from any of the sequences presented above (Cases 65 and 66, Figs 13-18). The formation of a sinus, by relief of tension, may be associated with relief of acute symptoms and increase in the range of movement. In one of our cases (Case 65) the diagnosis was confirmed by pressure over the proximal end of the sheath when pus was found to emerge from the sinus. In this type of case the incision should extend through the sinus, careful and thorough excision of all non-viable tissue is carried out, including conservative excision of the sinus edges, cellular tissue, sheath, and tendon. The sheath is washed out, penicillin is instilled, and whenever possible, the skin is sutured in the usual way. If suture is not possible, skin grafting is performed later (Case 66, Figs 16-18).

With third and fourth degrees of infection there may be necrosis of the tendon due to destruction at the site of the original infection, or to pressure from overlying structures at the flexor creases. As in all other types of infections of the hand, immobilisation in plaster is maintained until healing has occurred and only then are active exercises instituted.

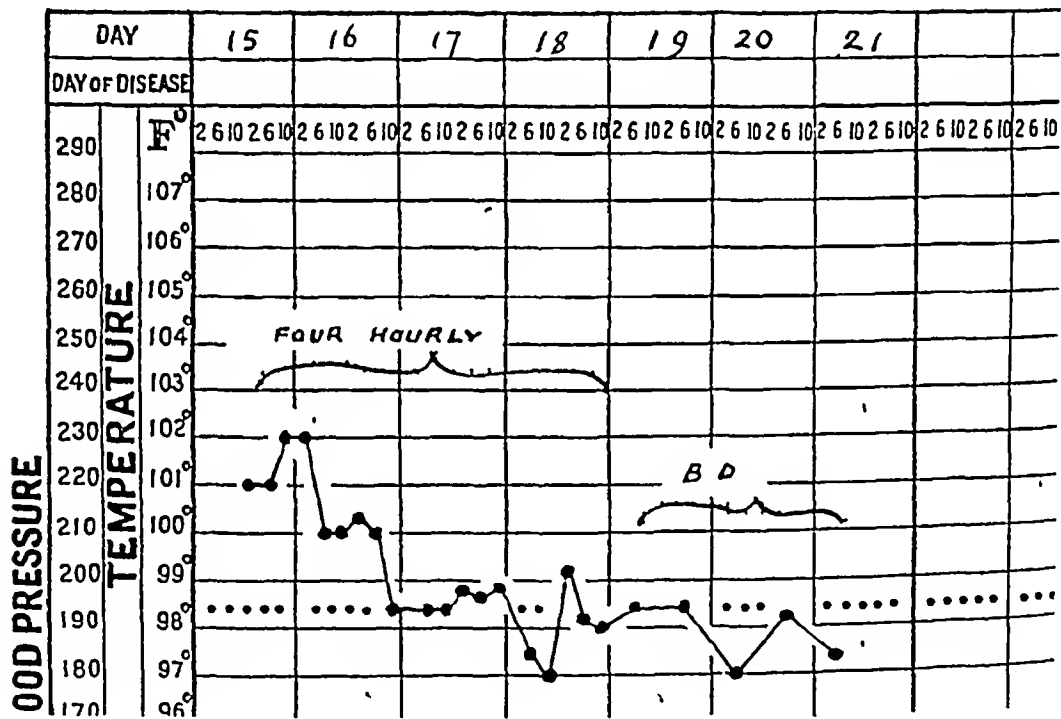


FIG 19

ILLUSTRATIVE CASES

**Case 3** Fitter, aged 21 years—Signs and symptoms of a second degree distal palmar pulp space infection at the base of the fourth digit of the left hand. He gave a history of having had a “web space” infection incised and drained in another hospital fourteen days earlier. The scar of the usual incision for a “web space” infection was well healed but clearly visible. Symptoms had never entirely abated since this operation and were becoming more severe. At operation a two limbed incision was made (Fig 2C). A small abscess with thick yellow pus was found directly under the distal palmar pulp. The web space itself was filled with scar tissue. Excision and suture was carried out. Healing occurred by first intention with complete relief of symptoms.

*Comment*—From the degree of surrounding fibrous tissue reaction it appeared probable that this abscess was the initial lesion in the original “web space” infection—the incision for which had succeeded only in draining the space and had left the initial focus of infection to become a residual abscess.

**Case 68** Carrier, aged 52 years—History of a thorn penetrating the radial side of the palm of the left hand. Two days later there were symptoms of acute inflammation and he was treated by his own doctor with poultices and M & B. He was referred to hospital eight days later and admitted as an in-patient on April 15 1947. He felt ill and had the signs of generalised toxæmia with yellow tint of face and mucosæ, furred tongue and a temperature of 101 degrees Fahrenheit (Fig 19). There was swelling of the radial side of the palm extending into the thenar region, the dorsum of the hand and the proximal segment of the index finger. The skin had broken down and an area of acutely tender soggy cyanosed skin surrounded a sinus discharging thick grey pus. There was axillary adenitis. The symptoms improved considerably after immobilisation and elevation of the limb with penicillin 200 000 units initially and 50,000 units three hourly and copious fluids. Nevertheless pyrexia continued. Ten hours after admission operation was carried out. All necrotic tissue was removed through an incision designed to excise the sinus. The skin edges were drawn together with loose nylon sutures but it was not possible to secure accurate apposition. April 16 swelling still present, pyrexia up to 100 degrees Fahrenheit, felt well and was free from pain. April 18 swelling practically gone, temperature 99 degrees Fahrenheit. April 19 temperature normal. April 20 elevation discontinued because swelling had disappeared. Active exercise of non immobilised parts encouraged, wound granulating well. April 21 discharged in plaster. May 7 pinch grafts applied to the granulating area. Healing occurred by May 13 with full function and good cosmetic result.

*Comment*—The improvement in general condition after rest, local immobilisation, and chemotherapy was very striking and the use of skin grafts in an area of skin loss undoubtedly hastened healing and the early restoration of function.

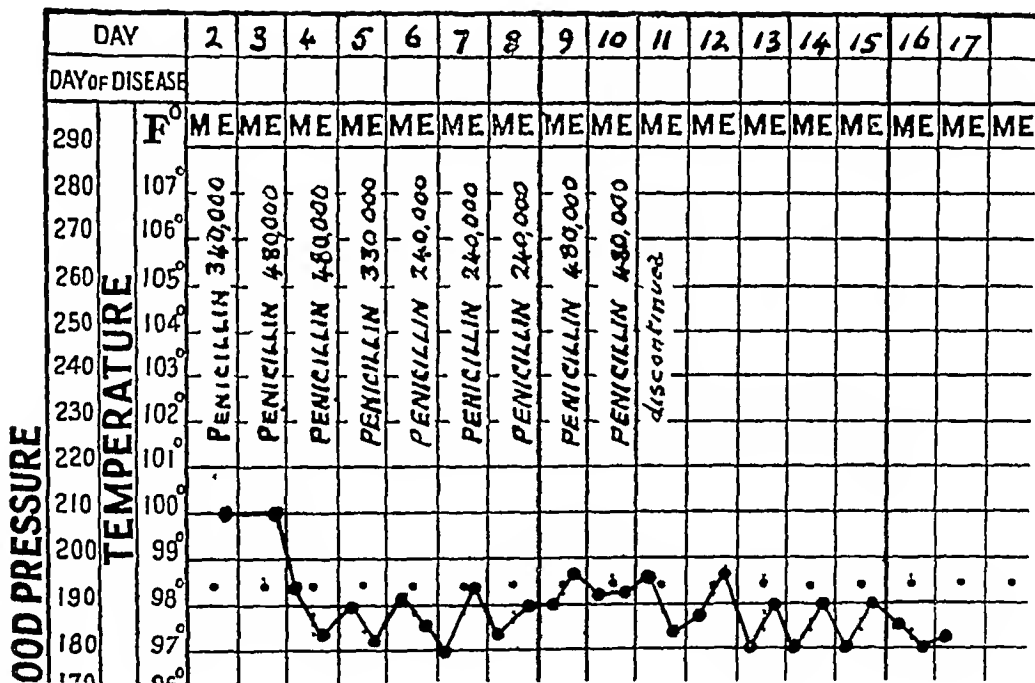


FIG 20

**Case 69** Cook, aged 83 years—The patient gave no history of trauma but stated that she woke on the morning of the fourteenth day before admission feeling ill and with a swollen left hand. Twelve hours later the forearm was swollen and red and she complained of pain in the axilla. She was taken to the local Cottage Hospital and given penicillin therapy. Twelve days later the swelling and redness of the forearm had diminished but there was no improvement in the hand. Incision and drainage of the proximal pulp space of the fifth digit gave no improvement. She was admitted as an in-patient to this hospital June 2 1947. General condition was fair with a pyrexia of 100 degrees Fahrenheit (Fig 20). Locally there was gross swelling of the left hand with obliteration of the normal palmar concavity, swelling of the proximal phalanges of the third, fourth and fifth digits and of the dorsum of the hand and lower quarter of the forearm with marked fluctuation just proximal to the flexor retinaculum. There was acute tenderness in all these areas. Movements of the fingers caused pain. There was an enlarged and tender supratrochlear gland. Twelve hours after admission after general and chemotherapeutic treatment the hand was explored. The proximal pulp of the fifth digit contained little pus.

but much granulation tissue. In the mid palmar space communicating with Parona's space there was a considerable quantity of thin yellow pus. This was washed out through two incisions: one as for a mid-palmar space (Fig 3A) and the other in the line of the proximal flexor skin crease of the wrist curving proximally along the subcutaneous border of ulna. All necrotic tissue was excised. The wound was sutured and the limb immobilised and elevated. June 4 temperature normal swelling going down symptom free. June 6 swelling disappeared. June 10, all wounds healed, chemotherapy discontinued and active exercises commenced. June 14 full and painless movements. June 16 discharged from hospital. June 23 returned to work final cosmetic and functional result perfect.

**Case 65** Farm labourer, aged 40 years—Gave a history of having been pricked by a thorn on the right ring finger two weeks before admission: the thorn entered the distal end of the flexor surface of the middle phalanx. One day later there was pain and swelling. Seven days later the finger was incised by his own doctor over the distal end of the middle phalanx. Fourteen days later there had been no improvement despite systemic penicillin and kaolin and magnesium sulphate dressings. He was referred to this unit and admitted as an inpatient on May 31 1947. Examination showed a finger double the normal size with an area of skin loss over the middle phalanx covered with granulations. There was swelling, redness and acute tenderness over the proximal phalanx. After immobilisation of the hand and the



FIG 21



FIG 22

**Case 62** Third degree tendon sheath infection showing limited interphalangeal movement

institution of penicillin therapy—50 000 units three hourly operation was carried out under general anaesthesia. The proximal phalanx was explored and an abscess found lying over the opaque and distended tendon sheath. Pressure at this point caused pus to emerge from the wound over the distal flexor crease. All necrotic tissue over the proximal phalanx was excised and the old wound then explored. In this region the tendon sheath had disappeared and the tendon was sloughing. Thorough excision was carried out including about two thirds of the width of the tendon. The proximal wound was sutured, the hand immobilised in plaster, and one gramme of sulphadiazine given four-hourly in addition to the penicillin. On June 5 the proximal wound was healed and the distal wound clean and granulating. All acute symptoms had subsided. The patient was discharged home. The distal wound healed by secondary intention in a further sixteen days.

**Final result**—Cosmetically this was good. There was full movement of all joints except the distal interphalangeal joint where there was only 25 degrees of movement and limitation of extension by 35 degrees (Figs 13-15). This caused no inconvenience and the patient refused physiotherapy on the grounds that the finger was perfectly satisfactory.

**Comment**—A case of fourth degree tendon sheath infection with necrosis of the tendon and extensive skin loss in which chemotherapy was discontinued on the fifth day after operation because the proximal wound was healed and the distal wound clean and granulating. There seems little doubt that if earlier skin cover had been obtained by skin-grafts scarring would have been minimised and better function of the distal interphalangeal joint obtained.

**Case 62** Housewife, aged 34 years—Sustained a cut with a nail over the middle pulp of the left fourth digit one week before admission. She had received no treatment other than fomentations. Examination showed the signs of a third degree middle pulp space infection. Had no movement of the finger without pain. At operation the tendon sheath underlying a pulp abscess was found to be thickened and opaque. A quantity of pus was washed out of it in the usual manner. Owing to an oversight she was allowed to return home after operation without immobilisation and this was not remedied until two days later (July 7, 1947). A plaster splint was then applied. She was symptom free and remained so until



FIG 23



FIG 24

**Case 63** Fourth degree tendon sheath infection, also involving the distal palmar pulp and the mid palmar space



FIG 25



FIG 26

**Case 63** Showing healing of the wound and function of the finger

July 12 when removal of the plaster showed that the wound was nearly healed. The plaster was removed and gentle exercises were started. Three days later it was found that the skin flap had sloughed over about half its extent and a small amount of superficial pus overlay granulation tissue. The area was cleaned and penicillin therapy continued. On July 19 the surface was ready for skin grafting which was carried out with pinch grafts on July 22. The grafts had taken by August 1. By August 17 the cosmetic effect was very good and there was fair movement of the two proximal joints but only about 5 degrees at the distal interphalangeal joint. One month later examination showed that there was very limited movement at the interphalangeal joints (Figs 21–22).

**Case 60 Fishmonger, aged 38 years**—Puncture wound with a nail in the distal flexor skin crease of the left index finger, five days before admission. Within twenty-four hours he had increasing pain, swelling and stiffness of the whole finger and was given penicillin 200,000 units daily together with sulphadiazine by his own doctor without improvement. He was admitted to this hospital for treatment as an out-patient on July 15 1947. He complained of marked tenderness and pain on movement in the area shown (Fig 7) especially on forced extension but there was fair active flexion—about 20 degrees at each joint. At operation the distal end of the tendon sheath was opened and turbid fluid emerged. The sheath was washed out, the wound sutured and a plaster splint applied. Penicillin treatment was continued 200,000 units twice daily as an out-patient. On July 19 the plaster was removed. The wounds were healed and there were no symptoms or signs of infection. Chemotherapy was discontinued. Active exercises were instituted. By July 25 full function had been regained (Fig 8).

**Case 63 Railway worker, aged 51 years**—Cut his right hand seven days before admission. The hand swelled and became painful. He received no treatment until he came to hospital as an out-patient on April 28 1947. On examination the hand was swollen (Figs 23-24). All movements of the fingers caused pain, particularly extension of the fourth digit where there was also tenderness down the line of the tendon sheath. At operation, which was carried out the same day, pus was found in the fourth web space and the tendon sheath was necrosed. Excision of all necrotic tissue including the sheath was carried out and the sheath was washed through with saline and penicillin from the distal end. Good skin cover was not obtained owing to skin necrosis but approximating sutures were used. He was given penicillin 400,000 units daily in three doses and sulphadiazine 1 gramme four hourly. On May 2 he was free of symptoms and the swelling had practically gone. The wound was clean and granulating by May 6. Since good skin cover could not be obtained a full thickness skin graft was applied. By May 15 this had only partly taken but the wound was healed by May 27. Full movements were then quickly obtained by the patient's own active exercise (Figs 25-26).

*Comment*—This was the only case where a full thickness skin-graft was used and the result was less satisfactory than after the use of pinch grafts.

**Case 64 School teacher, aged 24 years**—Developed infection of the proximal pulp space of the right third finger on May 14 1947. This was treated with penicillin 100,000 units twice daily but deterioration took place. She came to hospital on May 19 and presented the picture shown (Figs 11 and 12). Active movements of the finger were possible but limited, passive extension caused pain. There was tenderness over the line of the tendon sheath and the skin was devitalised and necrotic round a sinus. At operation pus was found in the tendon sheath and in the pulp space. The usual procedure was carried out including excision of the sinus edges. Healing occurred in eight days with full and painless movement of the finger.

## DISCUSSION

An attempt has been made to outline the rationale of an approach to the treatment of infections of the hand, which in some respects is new. The paper is in the nature of a preliminary report. Conclusions based on a series of only sixty-nine consecutive cases must obviously be tentative. It may be learnt from Tables I and II that thirty-eight cases without skin necrosis healed in an average time of 7.3 days, while the other thirty-one cases, with some degree of skin loss, healed in an average of 19.6 days. These figures serve to emphasize once more the importance of early diagnosis and treatment. Of these sixty-nine cases, 57 per cent had already received various forms of treatment before being sent to hospital, including penicillin and sulphadiazine therapy, and of these, 29 per cent had received surgical treatment elsewhere. It seems clear that two further points require emphasis: 1) chemotherapy alone, except perhaps in the very early stages of infection, does not influence the local lesion, 2) surgical treatment must be radical at whatever stage it is employed.

In these tables the time of healing was calculated in days from the date of operation to the date when healing was complete. When more than one operation was performed—as in the case of skin grafting after excision—the time of healing was calculated from the date of the first operation. Our criterion of healing was complete healing of the wound without surface moisture, granulation tissue, or scab. In all cases, except those where the functional result was imperfect (two in number), patients were able to return to work as soon as the

TABLE I

DISTAL PALMAR PULP SPACE (WEB SPACE) INFECTIONS								
Case No	Sex	Age	Occupation	Degree	Length of history in days	Previous treatment	Remarks	Time of healing in days
1	M	20	Student	2	2	None	Following rowing blister	9
2	M	27	Lorry driver	2	3	None	Blister	9
3	M	21	Litter	2	14	Iodo- incision	Incised as web space elsewhere. Residual abscess in distal palmar pulp	7
4	M	45	Litter	2	5	Penicillin	Blister	4
5	M	15	College servant	2	5	Penicillin	—	8
6	M	6	Schoolboy	2	3	None	Blister	4
7	M	37	Steelworker	3	7	Poultices	Blister	5
8	M	24	Groundsman	3	7	None	—	9
9	M	13	Schoolboy	3	2	None	—	6
10	M	6	Schoolboy	3	2	Poultices	Blister	8
THENAR SPACE INFECTIONS								
11	M	24	Engineer	2	6	Sulphonamides	Similar infection in same locality 6 months earlier treated by incision and drainage	8
12	F	38	Housewife	2	3	Poultices	—	6
13	F	43	Housewife	3	3	Penicillin	—	10
14	M	41	Vanman	4	2	Penicillin	—	12
15	F	57	Needlewoman	4	2	None	Treated with sulpha diazine only for 4 days post-operatively but without penicillin	6
16	F	61	Housewife	4	42	Penicillin incision and drainage elsewhere	In-patient for 5 days	12
MID PALMAR SPACE INFECTIONS								
17	M	20	Student	2	4	None	Rowing blister. Subsequently rowed before removal of sutures	5
18	M	51	Furnaceman	3	25	Penicillin incision and drainage elsewhere	Wound of previous operation unhealed	11



TABLE I—*continued*

DORSAL SPACE INFECTIONS								
Case No	Sex	Age	Occupation	Degree	Length of history in days	Previous treatment	Remarks	Time of healing in days
19	M	19	Gardener	2	3	Penicillin, Sulphadiazine	No post-operative chemotherapy	7
20	M	23	Steelworker	3	5	Penicillin Krohn	<sup>2</sup> Due to an insect bite	7
PROXIMAL PULP SPACES								
21	M	14	None	2	5	Soaks <sup>1</sup>	—	10
22	M	30	Driver	2	3	None	—	6
23	F	15	Domestic	2	4	None	No chemotherapy either pre- or post-operatively	7
24	F	15	None	3	7	None	—	7
25	M	16	Student	3	5	None	—	10
26	M	20	Student	3	5	Penicillin	Rowing blister Lymphangitis and adenitis on admission	8
27	M	25	Electrician	3	6	None	Also had accompanying paronychia which healed in 7 days. Chemotherapy — Penicillin for 2 days followed by sulphadiazine for 3 days	18
28	M	43	Printer	4	4	Penicillin incision and drainage else where	Discharging sinus after first operation not excised plaster removed on 4th day and exercises started	43
29	M	18	Canteen worker	4	4	None	Discharging sinus excised Compare with Case 28	5
MIDDLE PULP SPACE INFECTIONS								
30	M	14	Farm labourer	2	8	None	—	7
31	M	19	Factory worker	2	3	None	—	7
32	F	30	Housewife	3	5	None	Removed own dressing on 2nd day. No immobilisation. Skin graft on 14th day	32
33	M	34	Transport manager	3	7	None	Skin graft on 6th day	30
34	M	26	Plumber	3	3	None	—	16
35	M	23	Student	3	7	None	Rowing blister Subsequently rowed before removal of sutures	9

TABLE I—continued

DISTAL PULP SPACE INFECTIONS								
Case No	Sex	Age	Occupation	Degree	Length of history in days	Previous treatment	Remarks	Time of healing in days
36	F	17	Nurse	2	2	Poultice	—	4
37	F	32	Housewife	2	21	None	—	5
38	F	15	None	2	2	None	No chemotherapy either pre- or post operatively	5
39	M	38	Motor mechanic	2	6	Penicillin	—	10
40	F	5	None	3	2	None	—	9
41	F	48	Housewife	3	10	Kaolin	—	19
42	F	15	Domestic	3	5	Penicillin Kaolin	—	7
43	M	22	Woodworker	3	2	None	—	12
44	F	16	Domestic	4	7	Poultices	Poor cosmetic result	11
45	M	25	Student	4	8	Incision and drainage elsewhere	—	7
46	F	27	Housewife	4	2	Sulphonamides incision and drainage elsewhere	—	3
DORSAL SPACE (FINGER) INFECTION								
47	M	44	Farm labourer	4	21	Poultices	Extensive skin loss	21
PARONYCHIAE								
48	M	25	Electrician	2	6	None	Also had proximal pulp space (see Case 27)	7
49	F	29	Housewife	2	4	Kaolin	—	5
50	F	20	Domestic	3	2	Penicillin Kaolin	Culture of pus showed haemolytic streptococcus in addition to the usual staphylococcus aureus	8
51	F	65	Domestic	3	7	None	—	4
52	F	40	Housewife	3	2	None	—	6
53	M	47	Antique dealer	3	6	None	Also had proximal pulp space infections	8

TABLE I—continued

PULP SPACE (FINGER) INFECTIONS WITH OSTFITIS								
Case No	Sex	Age	Occupation	Degree	Length of history in days	Previous treatment	Remarks	Time of healing in days
54	F	39	Housewife	4 with osteitis	21	Sulphonamides Penicillin Two operations for incision and drainage elsewhere	Sequestrectomy carried out through shark-mouth incision, excising sinus Suture Final cosmetic result fair	10
55	F	43	Housewife	4 with osteitis	21	Penicillin Sulphonamides Kaolin incision and drainage	Sequestrectomy and suture Final cosmetic result good	16
56	M	27	Metal worker	4 with osteitis	7	Sulphonamides Kaolin	Terminal pulp a bag of pus on admission	15
57	M	65	Licensee	4 with osteitis	180	Incision and drainage elsewhere Dressings	Sequestrectomy and suture Final cosmetic result good	10
58	F	50	Housewife	4 with osteitis	42	Sorbs	Sequestrectomy and suture Final cosmetic result good	8
59	F	47	Housewife	4 with osteitis	6	None	Skin graft failed Osteitis amputation of terminal phalanx	68
TENDON SHEATH INFECTIONS								
60	M	38	Fishmonger	1	7	Penicillin Sulphonamides	Puncture wound in distal flexor crease index finger culture — staphylococcus aureus Full painless movements in 14 days	9
61	F	38	Housewife	2	4	Sulphonamides	Also had 2nd degree proximal, and 4th degree distal pulp space infection Pus in the tendon sheath but sheath intact Culture—pus cells Full painless movements in 14 days	7
62	F	34	Housewife	3	4	None	Also had 3rd degree middle pulp space infection Skin graft after break-down of skin over proximal pulp Cosmetic result good Functional result poor	36

TABLE I—continued

INDON SHFATH INFECTIONS—continued								
Case No	Sex	Age	Occupation	Degree	Length of history in days	Previous treatment	Remarks	Time of healing in days
63	M	51	Railway worker	4	7	None	Also had 4th degree distal palmar pulp which spread to mid-palmar space and tendon sheath Culture—staphylococcus aureus Functional and cosmetic result good	29
64	F	24	School teacher	4	5	Penicillin 100 000 units for 3 days	Also had proximal pulp abscess 4th degree Culture — staphylococcus aureus Cosmetic and functional result good	8
65	M	40	Farm labourer	4 with sloughing tendon	14	Penicillin incision and drainage elsewhere	Puncture wound Also had 4th degree proximal pulp abscess Tendon sloughing under distal flexor crease Culture — staphylococcus aureus In-patient for 5 days Functional result good except for limitation of extension of the terminal IP joint by 20 degrees Cosmetic result good	21
66	M	37	Motor mechanic	4 with extensive skin loss	3	Incision and drainage elsewhere	Tendon sheath sloughed skin graft on 6th day Final cosmetic and functional result good	36
MULTIPLE LESIONS								
67	M	51	Railway worker	3	7	None	Distal palmar pulp + mid-palmar space + tendon sheath infections (See Case 63)	29
68	M	52	Carrier	4 with extensive skin loss	5	Sulphonamides	Dorsal subaponeurotic space of hand and proximal phalanx of index finger + thenar space Skin graft on 22nd day Healed 6 days later	28
69	F	83	Cook	4	14	Penicillin incision and drainage elsewhere	Spreading infection from proximal pulp 5th finger into mid-palmar and Parona's spaces In-patient treatment	8

wound was healed, and in many cases work was carried on even while there was immobilisation in plaster

No contemporary control series was attempted, but a comparison may justifiably be made with those cases which attended the Casualty Department of this hospital in the six months immediately before the period covered by this survey. These cases had similar treatment by penicillin and sulphadiazine, they were treated as in-patients when necessary, and they came under the care of the same Accident Service which carried out the work reported in this paper. During this earlier period, however, surgical treatment was of the orthodox type, with the usual methods of incision and drainage. The average time of healing for these cases was 19.3 days, contrasted with 12.7 days for the present series.

TABLE II

Type of infection	Number of cases	Number of operations	Primary suture only	Skin graft	Amputation	Average time of healing (days)	Final result	
							Functional	Cosmetic
Distal palmar pulp space	10	10	10	0	0	6.9	Full	Good
Thenar space	6	6	6	0	0	9	Full	Good
Mid palmar space	2	2	2	0	0	8	Full	Good
Dorsal space	2	2	2	0	0	7	Full	Good
Proximal pulp space								
1st and 2nd degree	3	3	3	0	0	7.6	Full	Good
3rd and 4th degree	6	6	6	0	0	15.1	Full	Good
Middle pulp space								
1st and 2nd degree	2	2	2	0	0	7	Full	Good
3rd and 4th degree	4	6	2	2	0	21.7	Full	Good
Distal pulp space								
1st and 2nd degree	4	4	4	0	0	6	Full	Good
3rd and 4th degree	7	7	7	0	0	9.7	Full	Good
Dorsal space (finger)	1	1	1	0	0	21	Full	Good
Paronychia	6	6	6	0	0	6.3	Full	Good
Pulp space (finger) 3rd and 4th degree with osteitis	6	8	5	1	One term phalanx	21.1	Full	5 Good 1 Fair
Tendon sheath								
1st and 2nd degree	2	2	2	0	0	8	Full	Good
3rd and 4th degree	5	9	1	4	0	26	(Full 3 Poor 2)	Good Good
Multiple lesions	3	5	1	2	0	21.6	Full	Good
Total	69	79	60	9	1	12.7	—	—

Florey and Williams (1944), and Curr (1945), investigated two series from the point of view of penicillin therapy. Their results, where comparable in other respects with ours, are shown in Table III. These workers used local and systemic penicillin combined with surgical intervention.

Warning as to possible dangers of the proposed treatment—Certain features of the treatment which has been described are not without danger. The operative procedure is prolonged. All the facilities described are essential if it is to be executed properly. Wide exposure increases the possibility of damage to important structures, particularly if it is carried out by inexperienced surgeons.

The possibility of recurrence of local infection after excision, primary suture, and the application of a plaster splint, was considered at the beginning to be the main danger, but it transpired that this was not so. Only those patients who required skin grafts needed more than one operation.

TABLE III  
TIME OF HEALING IN THREE SERIES OF HAND INFECTIONS

	Present Series		Florey and Williams		Curr	
	Number of cases	Days in healing	Number of cases	Days in healing	Number of cases	Days in healing
Pulp space infections	26	11.8	22	21.7	18	23
Distal palmar pulp infections	10	6.9	9	18.8	12	13
Tendon sheath infections	7	20.9	10*	34.1	25	30
Paronychia	6	6.3	26	7.7	—	—

\* Excluding one bad case which healed in 180 days

Infections of the hand call for accurate diagnosis, careful and thorough surgery, and good supporting treatment and follow-up. A sympathetic approach to the patient's domestic and economic problems is important. Such work should not be relegated, as it so often is, to the unsupervised activities of junior house surgeons.

The results obtained suggest that a further trial of the method is indicated.

#### SUMMARY

1. A report is presented of the method and results of treatment of sixty-nine consecutive cases of infection of the hand.
2. Excision and primary suture, combined with chemotherapy and immobilisation in plaster, was the method of treatment.
3. The results, from the point of view of rapidity and completeness of recovery, justify consideration of the method for further use.

#### REFERENCES

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CURR, J. F. (1945) *Edinburgh Medical Journal* **52**, 469.

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# TRAUMATIC DISLOCATION OF THE HIP JOINT

## Review of One Hundred and One Dislocations

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The patients reviewed in this paper received all or part of their treatment in the orthopaedic centres of the Royal Air Force between June 1940 and June 1945. More than half of them were admitted to one of the centres directly after injury, and others were seen within the first few days. In many, however, initial treatment had been carried out elsewhere, often under circumstances of extreme difficulty, and several months had sometimes elapsed before the patient reached this country.

It must be stressed that one of the important problems in relation to traumatic dislocation of the hip joint, namely the exact incidence of late sequelae, is outside the scope of this review for the reason that it has not been possible to review all cases over a long enough time. The average period of follow-up is no more than three to four years, and this is far too short a time in which to estimate the frequency of traumatic arthritis due to avascular necrosis. This paper records only the early results of dislocation of the hip joint, and the complications developing during the first few years, in one hundred young and previously healthy adults.

### INCIDENCE AND MECHANISM OF DISLOCATION OF THE HIP JOINT

During the period under review, approximately 52,000 patients with major and often multiple injuries were admitted to the orthopaedic centres of the Royal Air Force. The incidence of dislocation of the hip joint was therefore one in every 520 patients. This frequency, as compared with that of dislocation of other joints, is of some interest. Analysis of 123 dislocations of the larger joints treated in the orthopaedic centre at Ely during this five-year period shows that it included eighteen dislocations of the hip, six dislocations of the knee, forty-two dislocations of the shoulder, and fifty-seven dislocations of the elbow.

Before the introduction of the motor-car, dislocation of the hip joint was comparatively rare, and the classical cause was wide and forcible abduction of the lower limbs, the limb acting as a long lever to force the femoral head through the inferior aspect of the joint capsule. In this series, only eight dislocations were of this type, and ninety-three were due to considerable violence of high-velocity acting in the line of the shaft of the femur. Fifty-three were due to crash landings and other aircraft accidents, thirty-six were due to motor-cycle and motor-car accidents on the road, one occurred in a railway accident, and two were due to crushing beneath falling masonry during air raids.

The exact nature of the dislocation depends upon the position of the limb when force is applied. If the hip joint is flexed and adducted, the head of the femur is driven out of the back of the joint where the capsule is weak and the acetabulum relatively shallow. With less flexion and less adduction the head is driven against the strong postero-superior buttress of the acetabulum which is fractured. If the hip is extended and abducted a central fracture dislocation is produced.

The relationship between anterior and posterior dislocation of the hip joint depends also upon the mechanism of injury. Dislocation caused by violence of high velocity is essentially an injury with posterior displacement of the femur, on the other hand dislocation due to abduction may be anterior or posterior according to the degree of external or internal rotation of the limb at the moment that abduction force is applied. The only anterior dislocations in this series were due to excessive abduction.

It was surprising to find that four men sustained dislocation of the hip joint while playing rugby football—an injury which hitherto has been almost unknown in this game. The explanation lies in the fact that the organised games of a military service are not always characterised by great skill or experience. In all four cases the injury was due to one player jumping heavily on the shoulders of the patient while he was in a squatting position and endeavouring to pick up the ball—both these manoeuvres being highly unorthodox.

In dislocations due to aircraft accidents the high percentage of associated injuries is important. No less than thirty of the fifty-three dislocations were associated with other major fractures of the limbs or spine, and two were associated with severe burns as well as fractures. One of the serious problems in the management of aircraft injuries is the frequency in a single patient of multiple fractures, dislocations, wounds, and burns.

**Classification of the various types of dislocation**—Dislocations of the hip joint can be classified into four main types: simple dislocations, dislocations with fracture of the acetabular rim, dislocations with fracture of the acetabular floor, and dislocations with fracture of the femoral head (Table I). Such classification facilitates consideration of the treatment, incidence of complications, and estimation of end-results, which differ widely in the four groups.

TABLE I  
CLASSIFICATION OF TYPES OF DISLOCATION IN A SERIES OF 100 PATIENTS  
(One Bilateral Dislocation)

Simple dislocation	Dislocation with fracture of acetabular rim	Dislocation with fracture of acetabular floor	Dislocation with fracture of femoral head
46 cases	43 cases	7 cases	5 cases

#### TREATMENT AND RESULTS IN SIMPLE DISLOCATIONS OF THE HIP JOINT

In simple dislocations of the hip joint management was relatively easy, and the results were much better than in any of the other types. The treatment of these cases soon became uniform throughout the R A F Orthopaedic Service, namely: reduction by manipulation under general anaesthesia, immediate immobilisation in a hip spica for eight weeks, mobilisation with non-weight-bearing exercise for about four weeks, and finally, treatment at a rehabilitation centre for a month or six weeks with gradual return to full activity but without the more strenuous forms of rehabilitation. In early days, some surgeons delayed the application of a plaster spica for twenty-four to forty-eight hours after reduction of the dislocation, but patients were more comfortable if the joint was at once immobilised completely, and this practice soon became general. In a few centres the joint was immobilised in a Thomas' knee splint with light traction, but no special advantage of such treatment was apparent. The period of complete immobilisation varied a little, but it was universal practice to defer weight-bearing for at least three months after injury.

The place of the rehabilitation centre in the treatment of these injuries was not, at first, quite clear. Many surgeons felt that it might not be desirable to permit strenuous rehabilitation. It became obvious, however, that patients who went to these centres were restored to full activity more quickly than those who did not, and rehabilitation did not cause any ill-effects. During the second half of the period under review the treatment of almost every patient was completed at one of the rehabilitation centres.

**Early results of treatment in simple dislocations**—The results are summarised in Table II. Patients were classified as normal if there was no muscle wasting, no limitation of movement, no radiographic evidence of abnormality, and no real discomfort after engaging



in full activity Of the forty-six dislocations, thirty-five (76 per cent) had no symptoms or disability remaining after a period of treatment ranging from four to seven months

TABLE II  
RESULTS IN FORTY SIX SIMPLE DISLOCATIONS OF THE HIP JOINT

Normal at the conclusion of treatment	35 cases
Calcification in capsule of joint (no disability)	2
Arthritic changes in the joint	6
Myositis ossificans	1
Avascular necrosis of the femoral head	1
Sciatic palsy	1
Total	46 cases

*Calcification of the capsule*—In two patients, radiographs taken at the conclusion of treatment showed a little calcification in the capsule of the hip joint, which, however, was not associated with disability

*Arthritis*—Six patients developed clinical or radiographic evidence of arthritis of the hip joint The clinical picture was fairly uniform there was slight wasting of the thigh, movement of the joint was limited by one-quarter to one-third of the normal range, and



FIG. 1

Traumatic subperiosteal ossification (myositis ossificans) after dislocation of the hip joint The joint had not been immobilised after reduction Massage and movements were continued throughout the first ten weeks

there was discomfort or aching pain which was made worse by exercise Radiographic changes were less definite In two cases, the radiographs showed no abnormality, in four, there was narrowing of the joint space, this being associated with decalcification of the femoral head in two In only one patient was the disability of such severity as to necessitate invaliding from the Service, the other five being able to continue duty in more sedentary branches

*Myositis ossificans*—One patient developed myositis ossificans Eight months after injury new-bone formation was obvious in the region of the muscles inserted round the hip,

there was limitation of movement and pain. This was one of the very few patients in the series whose hip joint had not been immobilised after reduction. "Massage and movements" had been ordered and this treatment was continued for ten weeks, after which time the patient was allowed to begin weight-bearing.

*Avascular necrosis of bone*—Avascular bone necrosis of the femoral head developed in one instance. Six months after injury, movement of the joint was limited to one-third of the normal range, there was pain and disability, radiographic examination showed patchy sclerosis of the femoral head.

*Sciatic palsy*—Sciatic paralysis occurred in one patient—a girl who was pinned under the wreckage of a demolished building for three and a half hours. On being dug out she was found to have a dislocation of the hip joint with sciatic paralysis. The dislocation was reduced and treated in the usual manner, but there was no evidence of recovery of the paralysis within ten months of injury.

**Late follow-up of simple dislocations**—After the war an attempt was made to secure late reports on as many as possible of the hundred patients. This proved difficult. Six had been killed in action while flying against the enemy, others had been demobilised, repatriated,

TABLE III  
FOLLOW-UP OF NINETEEN PATIENTS WITH SIMPLE DISLOCATION  
(Questionnaire completed by patient)

Normal	Five patients	Hips reported to be completely normal at periods ranging from 13 to 49 months after injury
	Six patients	Occasional trivial symptoms—aching and vague pains—reported 11 to 41 months after injury
	Three patients	Slight symptoms after exertion but no great disability 19 to 36 months after injury
Arthritis	One patient—at the fourth month there had been limitation of movement and pain	No change some pain and stiffness (44 months)
	One patient—at the tenth month there was aching and limitation of movement	No change slight aching and stiffness (41 months)
	One patient—at 9 months there was limitation of movement and aching	Pain stiffness and considerable disability (36 months)
	One patient—at 14 months there had been some pain and limitation of movement	Pain stiffness and increasing disability (24 months)
Avascular Necrosis	One patient—6 months one third normal range of movement with pain and disability	Painful stiff hip with considerable disability (41 months)

and scattered all over the Empire, and some were on service abroad. Strenuous efforts were made by Squadron-Leader Vere-Hodge to trace all cases and many were reviewed successfully by means of a printed questionnaire which was answered by the patient, a method which although not altogether satisfactory was in the circumstances the only practicable plan. Late radiographic examination was sometimes possible. The results of this investigation in the case of simple dislocations are summarised in Table III. Of the nineteen patients who were traced one to four years after injury, fourteen had been classified as normal at the conclusion of treatment. Of these, five reported that their hips were still quite normal, six

complained of occasional trivial aching or vague pain, and three complained of vague symptoms related only to exertion and not associated with serious disability.

Of the six patients classified at the conclusion of treatment as having clinical or radiographic evidence of arthritis, four were traced. Two had not become worse, both had some stiffness and pain after exertion but without much disability. One had been force-marched as a prisoner-of-war over a distance of 100 miles during the third year after dislocation and sustained the ordeal without any great trouble. The other two had symptoms and slight disability remaining three years after injury. The one patient in this group with early evidence of avascular necrosis of the femoral head was also traced. Forty-one months after injury his joint was very stiff and he had considerable pain and disability.

# TREATMENT AND RESULTS IN DISLOCATION OF THE HIP JOINT WITH FRACTURE OF THE ACETABULAR RIM

Effective treatment of dislocation of the hip joint with fracture of the acetabular rim must achieve not only reduction of the dislocation but also accurate replacement of the acetabular fragment. Moreover, reduction of the fragment must be maintained until it has united by bone. In many instances the acetabular fragment is replaced accurately when the dislocation is reduced. It is then necessary only to immobilise the joint until union has taken place, the plan of treatment being identical with that of simple dislocations. When complete reduction of the acetabular fragment was not secured by manipulation the usual practice was to immobilise the limb in traction, either in a Thomas' knee splint or by the Russell technique. In most instances the fragment fell back accurately into place within a few days.

TABLE IV  
RESULTS IN FORTY-THREE PATIENTS IN WHICH DISLOCATION WAS  
ASSOCIATED WITH FRACTURE OF THE ACETABULAR RIM

Normal after treatment (3 to 8 months)	27 cases
Died	2
Calcification in joint capsule (no disability)	1
Persistent displacement of acetabular fragment (no disability)	1
Arthritic changes in joint	9
Avascular necrosis of femoral head	1
Open reduction and mould arthroplasty	1
Injures to reduce dislocation	1
Total	43 cases
Sciatic paralysis	3 cases

In these circumstances traction was discontinued after five or six weeks and immobilisation was maintained by means of a hip spica. In one case, after successful manipulative reduction of the dislocation, a large fragment remained widely displaced and Wing-Commander J Crawford Adams undertook operative replacement and internal fixation of the displaced fragment. This case is of particular importance in relation to the associated sciatic nerve palsy, and it will be referred to later.

**Early results of treatment in dislocation with fracture of the acetabular rim**—The results are summarised in Table IV. Two patients died, one within forty-eight hours of crash-landing an aircraft in the course of which he received multiple severe injuries, and one from pneumonia which developed five weeks after injury.

*Calcification in the capsule*—In one instance there was calcification in the capsule of the joint but function was normal at the conclusion of treatment.

*Unreduced acetabular fragment*—There was persistent displacement of a large acetabular fragment in one patient. The fragment did not fall into place when the joint was reduced, traction, which was applied nine weeks after injury, had no effect. Ten months later the joint was clinically and functionally normal despite a somewhat alarming radiographic appearance.

*Arthritis*—Nine patients developed clinical or radiographic evidence of arthritis. In one, the

hip joint appeared to be normal six months after injury but radiographs showed narrowing of the joint space and lipping of the acetabulum. Four patients had some pain and slight limitation of movement at the conclusion of treatment although radiographs were normal. Three, with incomplete reduction of the acetabular fragment, complained of pain and stiffness.

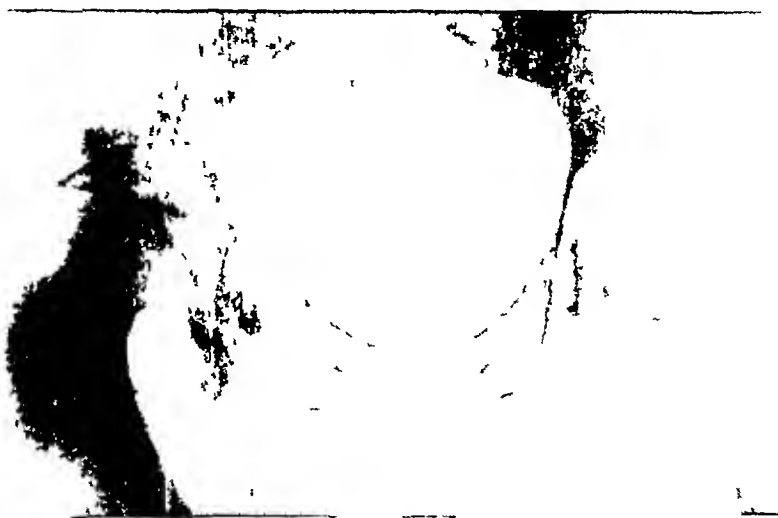


FIG 2

Posterior dislocation with fracture of the acetabular rim



FIG 3

Same case as in Fig 2 after reduction of the dislocation. The acetabular fragment has fallen accurately into place.

One patient who had been treated by massage and exercises immediately after reduction complained of pain and stiffness, and there was marked diminution of the joint space with lipping and new bone formation around the acetabulum.

*Avascular necrosis of bone*—Avascular necrosis of the femoral head occurred in one patient. This man was treated in a German prison camp. After repeated attempts to reduce the dislocation, various forms of skeletal traction were applied over a period of several weeks. Twenty-two months after injury the hip was fixed with 55 degrees of flexion and 20 degrees



FIG 4



FIG 5

Dislocation of the hip joint in which a large acetabular fragment remained displaced after reduction (Fig 4). There was sciatic palsy. Operative reduction and screw fixation was performed by Wing-Commander J Crawford Adams. The nerve was impaled by the point of the fragment. The paralysis recovered.

of adduction deformity. Radiographs showed patchy necrosis of the femoral head, complete loss of the joint space, and destruction of the acetabular socket.

*Unreduced dislocation*—In one patient who had sustained severe head injuries the dislocation was left incompletely reduced for three and a half months, at the end of which time there was fibrous ankylosis. Mould-arthroplasty was performed with a fairly satisfactory result. In one instance bilateral dislocations, sustained as the result of a railway accident, were left unreduced: one was central in type, the other was posterior and associated with fracture of the acetabular rim. Both lower limbs were immobilised in traction without any attempt at manipulative reduction. Although it became obvious as soon as traction was released that the dislocation was unreduced, the patient was encouraged to begin weight-bearing five months after injury, with consequent upward displacement of the femoral head. The opposite hip had ankylosed, and seven months after injury operative reduction of the dislocation was performed with some difficulty. Bilateral mould-arthroplasties were subsequently carried out, secondary revisions being required on both sides (one of these operations being performed in London by Dr Smith-Petersen).

*Sciatic paralysis*—Dislocation with fracture of the acetabular rim was associated with sciatic palsy of the external popliteal type in three instances. In each case a large acetabular fragment was widely displaced. In one, the fragment was reduced by operation five days after injury and the paralysis recovered almost fully within six months. In the second, the sciatic nerve was explored within seven months of injury and it was found to be compressed by the acetabular fragment. The nerve was freed but eight months later there was no evidence of recovery. In the third case, the acetabular fragment remained displaced, two years after injury there was still complete paralysis of the external popliteal division of the nerve.

TABLE V  
FOLLOW-UP OF PATIENTS WITH DISLOCATION OF THE HIP JOINT  
ASSOCIATED WITH FRACTURE OF ACETABULAR RIM  
(Questionnaire completed by patient)

Normal	Five patients	Hips reported to be completely normal at periods ranging from 21 to 48 months after injury
	Two patients	Trivial symptoms reported 45 and 48 months after injury
Arthritis	Five patients with arthritic changes at conclusion of treatment <i>Note</i> —In two of these patients dislocation was associated with sciatic palsy: the nerve was explored 7 months after injury in one case, 15 and 24 months after injury there was no recovery in either	No change or deterioration in condition of hip at periods of 14 to 63 months after injury
Calcification in joint capsule	One patient—calcification in joint capsule but no disability	28 months after injury aching pain and slight but increasing disability
Avascular necrosis of femoral head	One patient—avascular necrosis of femoral head	30 months after injury severe disability awaiting arthrodesis of hip
Mould-arthroplasty	One patient—mould-arthroplasty 3½ months after injury	48 months after injury half normal range movement 1½ in shortening no great pain

**Later follow-up of dislocations with fracture of the acetabular rim**—Fifteen of the forty-three patients in which dislocation was associated with a fracture of the acetabular rim were traced. The findings in this group are recorded in Table V. Of seven patients who had previously been classified as normal, five reported that their hips were still normal, and two complained of slight aching and stiffness. In five patients with an early record of arthritic changes the condition of the hip had remained unchanged. One patient with early calcification in the capsule reported that he had slight aching and could not sleep on that side. The condition of the patient with avascular necrosis of the femoral head remained unchanged and he was awaiting arthrodesis. The patient in whom mould-arthroplasty had been performed had satisfactory function with about half the normal range of movement.

TREATMENT AND RESULTS IN DISLOCATION OF THE HIP JOINT  
WITH FRACTURE OF THE ACETABULAR FLOOR

Of the seven dislocations in this group, three were of the central type with tilting of the ischium, and inward displacement of the head of the femur through the acetabular floor. Four were posterior dislocations with fractures involving the floor of the acetabulum.

**Results of treatment in central fracture-dislocations**—The three central dislocations were reduced with reasonable accuracy by traction. Nevertheless the results were uniformly unsatisfactory (Table VI). In two cases, ankylosis of the joint occurred; in one, the joint, though completely stiff, was stable and painless, in the other, the joint was unstable and arthrodesis was necessary. The third case showed clinical and radiographic evidence of arthritis six months after injury. If these results can be accepted as typical it seems clear that the most useful measure in the treatment of this injury is early arthrodesis of the joint. In selected cases, mould-arthroplasty may perhaps be indicated.

TABLE VI  
RESULTS IN SEVEN DISLOCATIONS ASSOCIATED WITH FRACTURE OF THE ACETABULAR FLOOR

Cases 1, 2 and 3	Posterior dislocations with fracture of acetabular floor. Dislocation reduced by manipulation	4 to 7 months after injury the dislocations remained reduced and the fractures were united. All had pain, limp and stiffness. Radiographs showed irregularity of the acetabulum and narrowing of the joint space.
Case 4	Posterior dislocation with fracture of acetabular floor. Dislocation not reduced—treated by traction	Not reduced by traction, three inches shortening and flexion adduction deformity. 2 years after injury unsuccessful attempt at operative reduction. 4 years after injury attempted ilio femoral arthrodesis with bone graft, unsuccessful. Sciatic paralysis.
Case 5	Central dislocation treated by traction	6 months after injury firm, painless ankylosis with hip in good position.
Case 6	Central dislocation treated by traction	Painful fibrous ankylosis of hip. Arthrodesis 14 months after injury. Sciatic paralysis.
Case 7	Central dislocation treated by traction	6 months after injury pain, limp and 30 per cent limitation of hip movement. Narrowing of joint space and irregularity of acetabulum.

**Results of treatment in posterior dislocation with fracture of the acetabular floor**—

Three of the four posterior dislocations were reduced by manipulation and immobilised in traction. After treatment they all showed clinical and radiographic evidence of arthritis and, although two resumed sedentary duties and the other was repatriated, it seems probable that arthrodesis, or possibly arthroplasty, will be needed sooner or later. The fourth posterior dislocation was in a patient who had also sustained *fifteen* major fractures of the limbs and spine as well as severe head and facial injuries—many of the fractures being compound and infected. During the last few years he has submitted to no less than forty-two operations. The dislocation, which was complicated by disruption of the pelvis and paralysis of the sciatic nerve, was treated by traction alone and it remained unreduced, there was much shortening and deformity. Two years later, the femoral head was replaced by operation into the distorted acetabulum. Subsequent attempts to arthrodesis the joint, first by means of a trifin nail, then by ischio-femoral fusion with tibial graft, and finally by means of iliac bone chips, all failed to secure sound fusion. Nevertheless stability has been gained and the patient is pursuing a reasonably active life.



FIG 6

First degree of central fracture dislocation. Although there is quite minimal central displacement the floor and roof of the acetabulum are so comminuted that arthritis will certainly develop.



FIG 7

Final degree of central fracture dislocation. In such a case although the femoral head can easily be pulled out of the pelvis by skeletal traction, tilting of the ischium and displacement of the floor of the acetabulum remain uncorrected and arthrodesis or arthroplasty is inevitable (Mr. Gallagher's case—not one of this series).



Two of these fracture-dislocations were complicated by paralysis of the sciatic nerve, in both there was comminution of the acetabular rim. In one, with central dislocation which was arthrodesed fourteen months after injury, there was severe causalgia of the foot associated with external popliteal paralysis. The sciatic nerve was explored seven months after injury and found to be deeply indented by two bone spikes in the region of the sciatic notch. Recovery was slow, and at one time causalgia was so severe that amputation was considered, a course which the patient much favoured. Twenty-two months after injury (fifteen months after exploration of the nerve) there was still hyperaesthesia of the sole of the foot and almost complete external popliteal paralysis. Paralysis of the external popliteal division of the sciatic nerve also occurred in the unreduced posterior dislocation, with residual paralysis of the anterior tibial and peroneal muscle groups and persistent pain and hyperaesthesia of the foot.

TREATMENT AND RESULTS IN DISLOCATION OF THE HIP JOINT  
WITH FRACTURE OF THE FEMORAL HEAD

In the treatment of dislocation of the hip joint with fracture of the head of the femur three factors had a bearing on the prognosis: 1) the degree of damage to the femoral head, 2) the ease with which displacement could be reduced, and 3) the accuracy of replacement of the femoral fragment.

**Early results of treatment in dislocation with fracture of the femoral head**—In three of the five patients it was found possible to reduce the dislocation by manipulation. In one,

TABLE VII  
RESULTS IN FIVE DISLOCATIONS WITH FRACTURE OF THE FEMORAL HEAD

Case 1	Dislocation with small fracture (approx. one sixth) of the femoral head	Dislocation reduced by manipulation accurate reposition of femoral fragment Spica 3 months. Joint normal in 8 months
Case 2	Dislocation with small fracture of femoral head. Sciatic palsy	Dislocation reduced by manipulation immobilised in traction. 7 months later hip normal but palsy (weak hamstrings below knee paralysis) still present
Case 3	Dislocation with fracture of larger fragment (approx. one quarter) of femoral head	Dislocation reduced by manipulation hip immobilised in plaster. 10 months later 50 per cent limitation movement 10 degrees flexion contracture and pain with increasing disability
Case 4	Dislocation with comminution of femoral head	One month after injury open reduction attempted and fragments of head re- moved. Hip unstable and 3 months later reduced once more by traction, and finally arthrodesed
Case 5	Dislocation with fracture of large fragment (about one half) of femoral head	Open reduction 4 months after injury femoral fragment removed. Function poor. arthrodesis 5 months later

dislocation was associated with fracture of a fragment consisting of about one-sixth of the femoral head which was replaced accurately by manipulative reduction. The hip was immobilised for three months, and within eight months of injury it appeared normal. Another dislocation with a similar femoral fracture was complicated by sciatic paralysis. The dislocation was reduced by manipulation, and the hip was immobilised in traction, but the fragment did not fall back into place. Seven months later the joint appeared normal but there was residual weakness of the hamstrings and complete paralysis of all muscles below the knee. In the third case there was a fracture involving one-quarter of the femoral head. This was reduced by manipulation and immobilised for three months. Ten months after

injury the range of movement was half the normal range, and there was slight flexion contracture of the hip joint with increasing pain and disability

In two dislocations with fracture of the femoral head manipulative reduction failed. In one the femoral head was comminuted. Operative reduction was attempted and a number



FIG 8



FIG 9

Dislocation of the hip joint with marginal fragment detached from the femoral head (Fig 8). The fragment was replaced almost perfectly by manipulative reduction of the dislocation leaving only slight thickening and new bone formation at the inferior aspect of the femoral head and neck (Fig 9).

of bone fragments were removed. Reduction proved unstable and some months later the femoral head was again replaced by gradual traction and the joint was arthrodesed. The other was associated with a fracture involving half the femoral head. Manipulative reduction proved impossible and four months after injury an open reduction was performed, the femoral



FIG 10

Dislocation with fracture of almost half the femoral head. Open reduction and subsequent arthrodesis was necessary.

fragment being removed. Function of the hip was poor and five months later the joint was arthrodesed.

**Late follow-up of dislocation with fracture of the femoral head**—Four of five patients were traced subsequently and the findings are recorded in Table VIII. The one patient whose joint was normal eight months after injury was still normal eight months later. In the patient whose hip appeared normal seven months after injury, but who had sciatic paralysis, there was some pain and stiffness sixty-one months after injury and the paralysis remained unchanged. The patient who had 50 per cent limitation of movement, 10 degrees flexion deformity and increasing disability ten months after injury had persistent pain and severe stiffness thirty-five months after injury, but he had not consented to the arthrodesis which had been advised. The patient whose hip had been arthrodesed eight months after injury was still comfortable twenty-one months later and reported that he could walk five miles without difficulty.

TABLE VIII

FOLLOW UP IN 100 DISLOCATIONS WITH FRACTURES OF THE FEMORAL HEAD  
(Questionnaire completed by patient)

	At conclusion of treatment	Follow-up
Case 1	8 months—normal	16 months—normal
Case 2	7 months—hip normal complete sciatic palsy	61 months—pain and stiffness after exertion sciatic paralysis complete
Case 3	10 months—50 per cent limitation of movement 10 degrees flexion contracture and increasing disability	35 months—severe stiffness pain and disability
Case 4	14 months—sound arthrodesis	29 months—hip painless walks five miles easily

### ANALYSIS OF THE RESULTS OF TREATMENT IN ONE HUNDRED AND ONE DISLOCATIONS

**Complete functional recovery**—Analysis of results at the conclusion of treatment shows that in this series of 100 patients with 101 dislocations, sixty-three were clinically, functionally, and radiographically normal. This perfect result was achieved in 76 per cent of simple dislocations, 63 per cent of dislocations with fracture of the acetabular rim, and 40 per cent of dislocations with fracture of the femoral head, it was achieved in none of the central

dislocations with fracture of the acetabular floor Just under 50 per cent of the patients in this group who were traced after an interval varying from two to four years reported that they were still free from all symptoms, just over 50 per cent complained of minor symptoms which were not associated with any disability It must be emphasized once more, however, that these are relatively short-term results and that they do not take into account the possibility of late complications such as arthritis developing after many years

**Capsular calcification and myositis ossificans**—Three patients showed radiographic evidence of calcification in the capsule of the joint, but in none was there disability Such capsular calcification, which is seen very often after dislocation of any joint, appears to be of no clinical significance In one case, however, there was definite myositis ossificans with extensive subperiosteal ossification round the joint Movements were limited and there was pain This was the only patient in the whole series who was treated by early mobilisation and weight-bearing and by "massage and movements" throughout the first ten weeks after injury The inference is obvious Myositis ossificans is an avoidable complication, it arises only when dislocations associated with capsular avulsion and haematoma formation are massaged, exercised, and mobilised before there is time for reattachment of the capsule and reabsorption of the haematoma

**Displacement of marginal acetabular fragments**—Fractures of the acetabular margin are often replaced by simple manipulative reduction of the dislocation When such replacement is not achieved by the initial manipulation, it is advisable to apply traction for a few days because in these circumstances the fragment often falls back accurately into place Even when this is not so, replacement may be relatively unimportant because, in at least one case, persistent upward displacement of a large fragment of the acetabulum gave rise to no disability, and in several others there was persistent backward displacement, which was difficult to demonstrate in radiographs, but which gave rise to no symptoms The position is very different, however, when such a marginal fracture of the acetabulum is associated with sciatic paralysis Accurate replacement of the fragment is then important (see next page)

**Displacement of the floor of the acetabulum**—When the floor of the acetabulum is comminuted and displaced by central fracture-dislocation, and by posterior dislocation with fracture of the acetabular floor, the prognosis, so far as function of the hip joint is concerned, is grave In not one of the seven such cases in this series was good function regained Although the possibilities of arthroplasty must still be kept in mind, it would appear that early arthrodesis is the most useful measure

**Unreduced dislocations**—The lesson to be learned from the two cases in this series in which the dislocation remained unreduced is that the subsequent management of such cases presents difficulties so great that an unsatisfactory result is inevitable Operative reduction of a dislocated hip, after many months or years, is a procedure of surprising difficulty Dissection of the displaced femoral head, and replacement of the head in the remnants of the acetabulum, may cause grave haemorrhage and serious shock The results of arthroplasty are uncertain, arthrodesis cannot be relied upon, no matter what operative procedure is pursued the results are imperfect It is the more important therefore to avoid the initial mistakes which account for this failure, namely, attempts to reduce posterior dislocation by traction alone, and reliance upon antero-posterior radiographs (without lateral projections) as evidence that reduction has been achieved

**Avascular necrosis and arthritis of the joint**—In very few patients in this series was there clear radiographic evidence of avascular necrosis of the femoral head One showed areas of relative sclerosis within six months of injury Another, treated in a German prison camp, soon developed stiffness and pain which steadily increased, and there were radiographic changes in the head of the femur But the incidence of this complication was less than had been expected Nevertheless there can be little doubt that in many cases the bone underwent

necrosis although radiographic evidence was lacking. One patient, not included in this series, sustained a dislocation of the hip joint which was accurately reduced and treated without weight-bearing for three months, his recovery appeared to be complete, he trained and served as a Commando, and only after an interval of five and a half years did stiffness and pain develop with radiographic evidence of complete crumbling of the femoral head. The fact that follow-up review is limited in this series to no more than a period of two to five years means that the estimated incidence of avascular necrosis cannot be relied upon. In any series of cases in which an attempt is made to estimate the frequency of avascular necrosis after injury to the hip joint, a follow-up period of not less than five to ten years is essential.



FIG. 11

Dislocation of hip joint with avascular necrosis. Symptoms first developed after three years and radiographic changes after five years. For the first three years the joint appeared to be normal. The incidence of avascular necrosis cannot be estimated in any series with shorter follow-up than five years.

**Early traumatic arthritis of the joint**—Evidence of traumatic arthritis of the hip joint developed within a few years in 26 per cent of patients. In some there was obvious mechanical distortion of the articular surfaces with destruction and degeneration of articular cartilage. This was true in every case of central dislocation with fracture of the acetabular floor, it was true in many cases of dislocation with fracture of the acetabular margin. But there were cases of simple dislocation and fracture-dislocation in which there was no evidence of mechanical derangement and yet the joint remained irritable, and there was muscle spasm, wasting, pain, and stiffness. Although radiographic evidence was lacking these were probably examples of avascular necrotic change. The total incidence of arthritis within four years of dislocation was 15 per cent in simple dislocations of the joint, 25 per cent in dislocation with fracture of the acetabular margin, 60 per cent in dislocations with fracture of the femoral head, and 100 per cent in dislocations with fracture of the acetabular floor.

**Sciatic paralysis**—In seven patients, dislocation of the hip joint was associated with paralysis of the sciatic nerve. In two the paralysis was complete, and in the other five there

was paralysis of the lateral popliteal division of the nerve. In six of these seven cases there was displacement of a bone fragment from the margin of the acetabulum into the region of the sciatic notch. The seventh was unusual in that the patient was pinned beneath the wreckage of a demolished building for three hours, with a degree of pressure which might well have been expected to cause nerve lesions even if there had been no dislocation. The significant finding is that six dislocations of the hip joint with posterior displacement of a large acetabular fragment into the sciatic notch were all associated with sciatic paralysis.

In only one of these seven cases was there complete recovery from the sciatic nerve lesion and that was the one in which an early operation was performed by Wing-Commander Crawford Adams five days after injury, the fragment was removed from the sciatic notch and replaced accurately in position. Two other cases were operated upon seven months after injury and in both the findings were described as "dramatic." In one the nerve was obviously compressed by the large acetabular fragment, in the other the nerve was deeply indented by two bone spikes in the region of the sciatic notch. After these late operations recovery was incomplete. The other four cases with displacement of acetabular fragments were not operated upon and they did not recover.

If these results, in the case of seven cases of sciatic paralysis in one hundred dislocations of the hip joint, can be accepted as typical the lesson is clear. Dislocation of the hip with fracture of the acetabular rim, and complicated by sciatic paralysis, should be explored at the earliest possible time after reduction of the dislocation. If pressure on the nerve is relieved in the early stages the outlook is good, if it is not relieved the chances of recovery are poor.

#### SUMMARY

- 1 One hundred patients with dislocation of the hip joint have been reviewed, many having been re-examined at intervals ranging from two to five years after injury.
- 2 There were forty-six simple dislocations, forty-three dislocations with fracture of the acetabular rim, seven dislocations with fracture of the acetabular floor, and five dislocations with fracture of the femoral head.
- 3 Complete recovery, as judged by clinical and radiographic examination, was observed in 76 per cent of simple dislocations, 63 per cent of dislocations with fracture of the acetabular rim, and 40 per cent of dislocations with fracture of the femoral head, in no case of dislocation with fracture of the acetabular floor was recovery complete.
- 4 Only in one case did myositis ossificans develop, and that was the only case treated by "massage and movements" throughout the first ten weeks after injury.
- 5 Avascular necrosis of the femoral head was recognised in a smaller proportion of patients than had been expected, but since the follow-up review extended only to four years after injury the results, in this respect, are unreliable. The incidence of this complication after injury to the hip joint cannot be assessed unless the follow-up period is at least five to ten years.
- 6 Early traumatic arthritis developed in 26 per cent of patients—in 15 per cent of simple dislocations, 25 per cent of dislocations with fracture of the acetabular margin, 60 per cent of dislocations with fracture of the femoral head, and 100 per cent of dislocations with fracture of the acetabular floor.
- 7 When central or posterior dislocations are accompanied by fracture of the acetabular floor, early arthrodesis is the treatment of choice.
- 8 Displacement of marginal acetabular fragments is usually corrected by manipulative reduction or by traction.
- 9 Sciatic paralysis in dislocation of the hip joint is nearly always due to damage of the nerve by a displaced acetabular fragment. In such cases, if the fragment is not replaced accurately by manipulation or traction, operative reduction is urgently indicated.

I am grateful to Sir Reginald Watson-Jones who stimulated me to undertake this study and to Mr Vere-Hodge who assisted so much in the follow-up of patients.

# DENERVATION OF THE HIP JOINT IN OSTEOARTHRITIS

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Resection of the obturator nerve in osteoarthritis of the hip joint was described in 1933 by Camitz, and in 1935 by Mol. After this simple operation pain sometimes disappeared completely, but the results were unreliable. The first attempts at more complete denervation, already hinted at by Mol, were published by Tavernier in 1945. His work aroused widespread interest. Although, according to anatomical investigations, innervation of the hip joint is most complicated, practically all the surrounding nerves seeming to take part in it, Tavernier contented himself with resection of only two nerves—the posterior branch of the obturator nerve on the anterior aspect, and the nerve to the quadratus femoris muscle on the posterior aspect of the joint.

## TAVERNIER'S OPERATION

The operation is carried out as follows. The obturator nerve is approached through a vertical incision on the medial side of the saphenous vein (Donkersloot, 1947, prefers an oblique incision parallel to the inguinal ligament, because healing of the vertical incision is often delayed and sometimes leads to keloid formation). The adductor longus and pectineus muscles are identified directly below the os pubis, and the pectineus is cut transversely near its origin. The anterior branch of the obturator nerve is then seen easily and freed upwards as far as the obturator foramen. The posterior branch of the same nerve is found only with difficulty because its more distal part is covered by the adductor brevis muscle, no more than a short stretch can be isolated between the obturator foramen from which it emerges and the upper border of the adductor brevis. If a small branch was found leaving the obturator nerve in the direction of the hip joint, Tavernier contented himself with removal of this branch and left the rest of the nerve intact, if not, the posterior branch of the nerve was removed. It must be said, however, that this does not seem to be a logical procedure. If the movements of abduction and adduction are still preserved to greater or less extent, the obturator nerve should of course be left intact and only the lateral side of both branches near the obturator foramen should be cleaned of fibres which might possibly reach the hip joint. In cases, however, where the movements of abduction and adduction have been lost, and especially if there is adduction deformity, abdominal resection of the entire obturator nerve is a more simple and effective procedure which has the advantage of interrupting every possible connection with the hip joint and at the same time preventing increase in the degree of the adduction deformity by paralyzing the adductor muscles.

For the second part of Tavernier's operation, the patient is turned face downward. An ample skin incision is made in a line running from the point half-way between the posterior superior iliac spine and the base of the coccyx, to the distal margin of the greater trochanter. The gluteus maximus is split in the same line, with the exception of the most medial part which contains the larger blood-vessels and nerves. The sciatic nerve is exposed, isolated carefully, and retracted medially. By gentle dissection the piriformis, gemelli, obturator internus, and quadratus femoris muscles are identified. The nerve of the quadratus femoris muscle is found at the medial end of the superior margin of the gemellus superior where it lies between the sciatic nerve and the pelvis. It is identified by pinching, which gives rise to contraction of the quadratus muscle. The nerve is removed and the wound closed. The operation should be carried out only after thorough study of the anatomical relations of the quadratus femoris nerve in the cadaver.

The most important sources of innervation of the hip joint which are left intact after this operation are the femoral (anterior crural) nerve, the accessory obturator nerve, and the superior gluteal nerve. Nevertheless, Javimer in his series of twenty-four operations observed good results in seventeen, fair results in five and complete failures in only two cases, all within two years after operation.

Donkersloot had ten good results in a total of thirteen cases. Oblatz (1948) obtained satisfactory relief in twenty-eight out of forty-two patients in whom abdominal resection of the obturator nerve together with resection of the quadratus femoris nerve was carried out. In the discussion of Oblatz' paper, Kaplan stated that in his opinion the effects of the operation were due to "indirect neurotomy," that is to say, denervation of spastic muscles surrounding the joint. Padovan (1947) extended the operation to branches of the femoral (anterior crural) nerve and said that in this way complete denervation of the hip joint was obtained. From the anatomical standpoint, however, this seems impossible, and apart from this there arises the question as to whether complete relief of pain can reasonably be expected after an operation on the joint nerves. It is well known that pain in osteoarthritis and similar affections arises not only in the joint itself but also in the surrounding muscles, tendons, and fasciae.

### RESULTS OF DENERVATION OF THE HIP JOINT

As to our own results, we were able to review forty-eight patients in whom Tavernier's operation had been carried out by members of the staff of the orthopaedic department of the Amsterdam Municipal Hospital. In forty-three of these patients an operation was performed only on one hip, in five, a bilateral operation was performed.

TABLE I

TAVERNIER'S OPERATION FOR OSTEOARTHRITIS OF THE HIP JOINTS  
Results after a period varying from six to eighteen months after operation

Result	Number of patients			
	Total	Males	Females	Bilateral operations
Good	11	7	4	2
Fair	15	3	12	2
No improvement	22	5	17	1
Total	48	15	33	5

Excellent results have been very rare in our series. Only two men have been able to resume their work, as a carpenter and a decorator respectively. Cases in which the patient had little or no pain at the time of review, and walked considerably better than before operation, were classified as "good." Patients with a good result were on the whole energetic and cheerful people who collaborated fully in regaining the greatest possible degree of activity. Their general condition was good (normal blood pressure, reasonable body-weight, and no signs of generalised osteoarthritis). All our patients had serious forms of osteoarthritis of one or both hip joints with gross anatomical changes, all had undergone prolonged conservative treatment without benefit and had suffered for many years before the operation, many had lost all movement in the joint except for a few degrees of flexion movement, some had flexion-adduction deformity.

**Clinical features common to patients gaining benefit from denervation**—We looked for common features in the local condition of the joint in the comparatively small group of



patients who derived benefit. Such features might have enabled us to select suitable cases for future operations. But we looked in vain. Inability to select patients in whom a good result might reasonably be expected, together with the inevitable risks of thrombophlebitis, pulmonary embolism and infection (which in our series we could not wholly dismiss, despite rigid asepsis and modern chemotherapy) made us eventually discard denervation of the hip joint as an independent operation. Even in those cases occurring so frequently in which the general condition of the patient made it impossible for us to consider the major operations of arthrodesis and arthroplasty, we found that denervation failed to fulfil expectations.

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# TREATMENT OF PATHOLOGICAL DISLOCATION OF THE HIP JOINT AFTER SUPPURATIVE ARTHRITIS IN INFANTS

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*Paper read at the Annual Meeting, of the British Orthopaedic Association 1947*

From the point of view of its effect upon the hip joint, acute suppurative arthritis in infants is to be regarded as an entirely distinct disease from the suppurative arthritis which occurs in later childhood and adult life. Throughout the first year of life the head of the femur is formed entirely of cartilage, and even in the neck of the femur the component of bone is comparatively small and ill-formed. It is not until about the seventh month of life that the epiphyseal centre for the femoral head can be seen radiographically. At the age of one year the epiphysis still forms only a small part of the femoral head. Phemister (1924) has shown that cartilage undergoes rapid solution in pyogenic exudates, and in nearly all cases where frank suppuration has occurred this gives rise to complete destruction of the femoral head and pathological dislocation of the joint.

In older children, where there is a larger bone element, the course of the disease is less acute, there is a more chronic grumbling infection, and as the bared surfaces of bone come into contact with each other, ankylosis occurs with relative frequency. Marked destruction of the femoral head can of course occur in suppurative arthritis after the age of one year (the arbitrary limit which has been set for this group) but this destruction, and the consequent dislocation, become less likely as the bone component of the head becomes dominant. Indeed most of the cases reported in this paper first developed infection during the first nine months of life.

These cases presented themselves at varying ages of childhood and adolescence with a dislocated hip, a short leg, and a limp. In treating such cases the ideal at which to aim is of course a stable, movable, and painless joint with a limb of approximately normal length. How nearly can this be accomplished? At what stage is treatment best undertaken? I have records of seventeen such cases, all but one of which were unilateral. One died some years ago after successful arthrodesis of the joint, three I have been unable to trace, fourteen have been traced and re-examined. The treatment of these seventeen cases included one reconstruction of the Colonna type, four subtrochanteric osteotomies, eleven cases of arthrodesis of the hip, and one who has not yet been treated surgically. The follow-up period after operation varied from one to eighteen years, with an average for the whole series of ten years.

**Displacement osteotomy**—Of these three operations the simplest procedure, recommended by Ombredanne and many others, is an osteotomy of the Lorenz bifurcation type, or the subtrochanteric displacement osteotomy which is similar. Such osteotomy increases the stability of the joint but it does nothing to restore true length of the limb. Of the four cases in which this operation was performed, only one can be regarded as successful. She has a firm fibrous ankylosis with no hip movement. In the other three cases, despite post-operative radiographic appearances which suggested satisfactory displacement of the femur and good stability of the joint, the femoral head continued to travel upwards on the ilium and there was increasing flexion-adduction deformity with secondary lordosis and scoliosis. On the other hand when subtrochanteric osteotomy was performed as a secondary operation in cases of failed arthrodesis, the results were excellent. One such case united by bone (Figs 1-3) and the other developed a stable and painless fibrous ankylosis (Figs 4-5). It would appear therefore that osteotomy is of little value unless stability has first been achieved by other operative procedures.



FIG. 1

Girl with pathological dislocation of the hip joint due to acute suppurative arthritis at the age of nine months. Same case as Figs. 2 and 3.



FIG. 2



FIG. 3

Attempted arthrodesis at the age of eight years was unsuccessful (Fig. 2). Six years later at the age of fourteen years subtrochanteric osteotomy was performed. The joint then fused soundly (Fig. 3).

**Arthroplasty**—The one case in which arthroplasty was attempted at the age of eight years was a failure. It was done as an experimental alternative to arthrodesis, but the hip redislocated within a few months and the young lady, now aged twenty-three years, has over two inches of shortening and a waddling gait. Professor Leveuf (1945 and 1946), in a recent review of fourteen cases, recommended arthroplasty with transfer of the great trochanter downwards on the shaft of the femur. The limb was put up in wide abduction. Three months later a secondary osteotomy was performed just below the new attachment of the trochanter, and the limb was then adducted to the neutral position. He believed that the age of three years was the best time for such a procedure. But his follow-up period is less than five years and I think it is probable that early arthritis will develop as adult life is reached. Smith-Petersen advocates cup-arthroplasty in such cases, but not before the patient is in the late 'teens or early twenties. Theoretically this is the perfect answer for such cases, but it must be recognised that by arthrodesis the child can be restored to normal activities at an earlier age.



FIG 4



FIG 5

Boy aged eight years with pathological dislocation of the hip joint due to infection at the age of nine months (Fig 4). Attempted arthrodesis was unsuccessful but after subtrochanteric osteotomy which was performed twelve months later sound fibrous ankylosis was secured in good position and the result is satisfactory (Fig 5).

**Arthrodesis**—Our best results without question were those in which the joint was arthrodesed. This has given a result which satisfies more of the criteria of normality than any other method. It has given a stable, strong, and painless hip (Fig 6). Freeing of attachments over a considerable area of the upper end of the femur has made it possible to reduce real shortening, in one case from three and a half inches to one inch. Of the eleven cases so treated, sound bone fusion was secured within a few months in seven (one other fused soon after late osteotomy). Of the four cases operated on after the age of twelve years, all united. On the other hand only three of the seven patients operated on before the age of nine years fused successfully. A small trifin nail or bone peg was occasionally used (Fig 7).

*Optimal time for arthrodesis*—There would appear to be three good reasons why arthrodesis of the joint should be delayed in such cases until the age of twelve or thirteen years. 1) there

is general agreement that it is difficult to secure sound bone fusion in the earlier age group, 2) in young children it is possible for an active life to be pursued without complaint, despite the ugly, lurching gait and the tendency to tire easily, 3) if arthrodesis is attempted in the young child, flexion-adduction deformity may develop in consequence of the strong pull of flexor and adductor muscles on a limb which is still growing, and this may occur even after bone fusion has been achieved

*Pain in the back after arthrodesis*—Only one patient in this series showed evidence of pain in the back after arthrodesis, which in her case was performed eighteen years ago at the age of fourteen years. Nevertheless this causes her no real trouble, she leads a normal life, she is very fond of walking, and she tells me that recently she has walked as much as forty miles in a day! It has been argued that the extra strain on the lumbar spine after arthrodesis is a contra-indication to the fusion of a hip. On the other hand an unstable hip with a short leg and lurching gait is much more likely to throw excessive strain on the spine than an arthrodesis in good position done at an age when adaptation is still good.



FIG 6

Pathological dislocation of the hip joint at the age of three months treated successfully by arthrodesis at the age of eight years



FIG 7

Pathological dislocation of the hip joint treated by arthrodesis at the age of thirteen years showing use of the miniature trifin nail

*The problem of shortening*—The problem of real shortening in these limbs is best dealt with by a procedure which brings the trochanter down as nearly as possible to its normal level. In performing an arthrodesis, as opposed to cup arthroplasty, this requirement is much more easily satisfied because there is no contra-indication to wide clearance of muscular and ligamentous attachments at the upper end of the femur. After stripping the femur, the rawed trochanter can be slid into the bed of the old acetabulum by means of a skid. For the purposes of immediate stability the limb may be put in a wide degree of abduction and brought to a correct position a few weeks later. Where severe degrees of shortening need to be corrected this procedure has been reported to cause sciatic nerve palsy due to stretching, but no such case occurred in this series, and in any event such paralysis is unlikely to be more than transient.

No matter how accurately the trochanter is replaced at the level of the original acetabulum some residual shortening is of course inevitable not only because the head and

neck of the femur have been destroyed but because there is impaired growth of the limb. Such real shortening can sometimes be compensated by abduction at the time of arthrodesis. In other cases late operations for the equalisation of limb length may be desirable.

**Summary**—Arthrodesis of the hip joint performed between the ages of twelve and fifteen years, is the most satisfactory treatment for cases of pathological dislocation after acute suppurative arthritis in infants.

I would like to thank Sir Harry Platt for his help in the preparation of this paper and for his permission to publish it.

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#### DISCUSSION

Professor Leveuf (Paris) said that his preference was for arthroplasty of the joint. Nevertheless he acknowledged the excellence of the results of arthrodesis reported in this series. Mr Stirling (Edinburgh) said that in three cases he had transplanted the trochanter with its epiphysis to the stump of the neck. The epiphysis had not grown as he had hoped but good stability had been maintained and arthrodesis at a later date had been facilitated.

# FRACTURE-SUBLUXATIONS OF THE SHOULDER

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*From the Orthopaedic Service of the Manchester Royal Infirmary*

*Paper read at the Annual Meeting of the British Orthopaedic Association  
in Manchester October 1947*

Fractures of the upper end of the humerus are not uncommonly associated with downward subluxation of the head of the humerus from the glenoid. This fact appears to have passed almost unnoticed. It may have been thought that spontaneous recovery would occur, or that no permanent ill-effect would result, but though often correct, neither of these suggestions is quite true.

In a search of the literature, mention of this type of downward subluxation was found only twice. Cotton (1921) described it after fracture of the neck of the humerus in nine patients, eight of whom were heavily-built, elderly women. He ascribed the subluxation to fatigue of the muscles supporting the weight of a heavy and swollen arm which was held only by a collar and cuff sling. He directed his attention to improving the muscle tone.

Dehne (1939), in an analysis of fractures of the upper end of the humerus, included a group of fracture-sluxations most commonly due to a combination of adduction behind the body line and impaction. He stated that the subluxation was noted at once and that it was not necessarily downwards. He gave no statistics, and no explanation of the mechanism.

## CLINICAL MATERIAL

In a review of 115 fractures of the upper end of the humerus, treated at the Manchester Royal Infirmary, twelve patients (10 per cent) were found to have had downward subluxation of the shoulder joint at one time or another. Only the last eighty cases formed a continuous series. In this group there were five examples of subluxation. The incidence therefore is much less than 10 per cent.

Of the twelve patients, eleven had fractures of the humeral neck, seven of the abduction type (Fig 1), and four of the adduction type (Fig 2). The twelfth case was seen three weeks after reduction of a dislocation with fracture of the greater tuberosity (Fig 3). Reduction had been confirmed by radiographs, the displacement of the tuberosity suggested a torn rotator cuff, and this lesion was found later at operation. In five of the eleven patients with fracture of the neck of the humerus, there was such displacement of the greater tuberosity as to suggest that the fragment was completely free (Fig 4), and that there was loss of muscle function as in the case with a torn rotator cuff. The significance of these findings is discussed later. In one patient there was a fracture of the glenoid fossa.

The ages varied from twenty-four to eighty-two years, three patients were under forty and nine were over fifty years old. Eight patients were women, four were men. It was noted that some at least were of slender build. There was no nerve lesion in any of the twelve patients.

These patients fall naturally into two groups, six in whom subluxation was present at the first attendance, and six in whom it first appeared several days or weeks later. The first group all had fractures of the abduction type. In impacted abduction fractures the head is often levered outwards from the glenoid fossa as the limb returns to the side, thus leaving the articular surface facing upwards or even outwards, this may have been a factor in four of these six cases. Nevertheless many such fractures are seen in which rotation of the head occurs without downward subluxation.



FIG 1

Case E H Abduction fracture-subluxation one week after injury. There was no subluxation immediately after injury.



FIG 2

Case G C Adduction fracture subluxation one day after injury. There was no subluxation immediately after injury.



FIG 3

Case W L Subluxation observed four weeks after reduction of dislocation with fracture of the greater tuberosity.



FIG 4

Case A B Fracture subluxation immediately after injury showing the greater tuberosity quite disconnected from humerus.





FIG 5

Subluxation due to downward traction of the upper limb  
in a normal subject who was conscious



FIG 6

Subluxation from downward traction of the  
upper limb in a normal subject who was  
anaesthetised



FIG 7

Subluxation in anaesthetised normal subject  
showing rotator cuff drawn down by negative  
pressure in the joint

### DIAGNOSIS

Even in the early group, where there is marked swelling, clinical diagnosis is often possible. A gap can be felt between the acromion process and the humeral head, which appears to lie rather low. The gap may sometimes be increased by applying gentle traction to the limb. It usually closes when the elbow is elevated with the limb by the side, and when the patient lies down or braces the muscles. In some cases, however, this apparent reduction is incomplete and it may be accompanied by increased anterior angulation at the fracture site. The final diagnosis depends upon radiographic examination.

Two questions at once arise. Why do these subluxations occur? What, if any, treatment is required?

### ETIOLOGY OF THE SUBLUXATION

There appear to be three possible explanations. First, the subluxation may result directly from the violence of injury. The mechanics of these dislocating forces have been analysed by many authors, and the writer has nothing to add, subluxations are not the monopoly of any one fracture pattern. Yet if the force is insufficient to carry the head past the glenoid margin, the position of the head is unstable, and the shape of the bone ends and the tension of muscles might well be expected to reduce any remaining subluxation. The primary injury cannot be the sole cause, and in any case it would not explain the group in which there was late onset of subluxation.

Secondly, it is possible that there may be weakness of some muscle which normally retains the humeral head in the glenoid. In half the patients there was evidence of rupture of the rotator cuff, or fracture of its bone attachment. It is, however, very difficult to test supraspinatus function in recent injuries, pain and spasm restrict active movement, and the trapezius interferes both with palpation of the contracting muscle and with electrical stimulation. An attempt to stimulate the supraspinatus with the tip of a faradic needle, the shaft of which was insulated, proved too painful when sufficient current was used to move the limb. Tests on the cadaver in connection with supraspinatus function are described later.

Thirdly, as Cotton (1921) first suggested, the subluxation may be due to loss of tone in the longitudinal muscles from the scapula—namely, the biceps and coraco-brachialis, the long head of triceps, and particularly the deltoid. This suggestion receives support from the clinical finding that the subluxation of the head of the humerus is reduced when gravity is eliminated or when the muscles are braced. Only three patients had been treated at any stage in wide abduction, all the others had worn a collar and cuff sling, a device which favours stretching of the longitudinal muscles.

### EXPERIMENTAL INVESTIGATIONS

To investigate the degree of subluxation which is possible in the normal shoulder, conscious subjects were laid on the X-ray table and strong traction was applied with the limb by the side, countertraction was maintained by means of a soft towel around the axilla. Some downward movement of the head was constant but usually it was very slight (Fig 5).

Using the same method of traction under anaesthesia, quite severe subluxation could be produced regularly without great force being applied (Fig 6). Negative pressure is created in the shoulder sufficient to draw the rotator cuff towards the joint cavity\* (Fig 7).

A number of dissections and radiographic examinations were performed in the post-mortem room to determine which structures prevented the head of the humerus from sliding out of the glenoid fossa when the limb was pulled downwards. The results may be summarised

\* It is obvious that the subacromial bursa and surrounding tissues must be greatly stretched in this manoeuvre and it has therefore been used in manipulating stiff shoulders. Even in a conscious patient this manoeuvre alone may give striking improvement in the range of movement.

thus 1) all structures running down the arm from the shoulder, including vessels and nerves, play some part in maintaining congruity of the joint, 2) if the whole rotator cuff is divided the force necessary to subluxate the joint is slightly, but only slightly, diminished, 3) if all structures except the supraspinatus are divided, the force necessary to produce subluxation is very small, 4) the glenoid labrum appears to be too thin and pliable to have much stabilising effect

Attempts were made to determine what part an effusion into the joint might play. Air or water injected into the joint cavity did not alter the stability of the joint significantly, but it was found impossible to maintain any great tension owing to leakage under the subscapularis and down the long head of biceps. Attempts at arthrography of the shoulder by the injection of air in two living subjects were vitiated for the same reason. This finding may account for the fact that marked hydrops is seldom seen in pathological shoulder joints.

We were therefore driven to conclude that the most important factor in retaining congruity of the shoulder joint was the tone of the muscles running longitudinally, although



FIG. 8

Patient with a torn rotator cuff attempting to abduct the upper limb: the humerus is displaced upwards and the neck of the humerus faces the glenoid.

the spinati may have played a minor part. In this connection Fig. 8 shows the shoulder of a patient who, clinically, had a complete tear of the rotator cuff; the humeral head subluxated upwards when abduction was attempted, but there was no instability on downward traction.

#### THE RATIONALE OF TREATMENT

In these cases most of the fractures did not need reduction *per se*. The commonly accepted method of treatment, when controlled fixation or abduction is not indicated, is to use a collar and cuff sling with an axillary muff. But what advantage is gained from traction by the weight of the limb? Those few fractures which are unstable usually need more fixation than this, and it is suggested that others gain no benefit from the intermittent traction of a collar and cuff sling, which in any case is ineffective at night. By this method, damaged muscles are submitted to a stretching force which they may be unable to withstand, and in some cases the shoulder is subluxated. It is true that when the subluxation was overlooked or disregarded many showed no persistent subluxation, or loss of function directly attributable



FIG 9



FIG 10

Case R O N Fig 9 shows the subluxation observed three weeks after a fracture of the neck of the humerus Radiographs twelve months later show that the displacement has been spontaneously corrected (Fig 10)



FIG 11



FIG 12

Case F T Adduction fracture with subluxation five years after injury There is evidence of arthritis and avascular necrotic change Fig 11 is a radiograph taken with the muscles relaxed In Fig 12 the muscles are braced

to this lesion (Figs 9-10) But the subluxation may persist, and it did so three times in this series of twelve The joint feels unstable, and the onset of arthritis must surely be accelerated by the head sliding up and down in the glenoid (Figs 11-12) In most cases a triangular sling which gives support to the elbow prevents or corrects the subluxation without interfering with the fracture, while physiotherapy rapidly improves the muscle tone and prevents recurrence

In the few cases in which the support of a triangular sling is insufficient, or in which it causes forward angulation of the fracture, both the fracture and the subluxation should be reduced and the arm fixed for a few weeks in abduction and forward flexion by means of a plaster spica, with careful support under the humeral head

### SUMMARY AND CONCLUSIONS

- 1 Attention is drawn to the not infrequent occurrence of downward subluxation of the shoulder joint accompanying fractures of the upper end of the humerus
- 2 Such cases fall into early or late groups according to the time of onset of the subluxation
- 3 The subluxation often disappears spontaneously, but it may persist and cause disability It cannot safely be disregarded
- 4 The etiology is discussed and experiments are described which lead to the conclusion that the subluxation is due chiefly to lack of tone in the scapulo-humeral muscles supporting the weight of the limb
- 5 It is suggested that the use of a collar and cuff sling as a method of treatment for fractures of the shoulder is not without danger A triangular sling usually prevents or cures the displacement

The writer wishes to thank Sir Harry Platt for advice and criticism in this work

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### DISCUSSION

Mr Pridie (Bristol) suggested that the subluxation might be due to traumatic hæmarthrosis Sir Reginald Watson-Jones (London) said that similar subluxations occurred in tumours of the upper shaft and neck of the humerus where there was no traumatic factor and no hæmarthrosis the coincidence of gravitational pressure and muscle hypotonicity was no doubt the explanation of subluxations which developed secondarily in the course of treatment He congratulated Mr Fairbank on successfully challenging so classical a measure as the treatment of fractures of the neck of the humerus in a collar and cuff sling even the apparent fundamentals of treatment called for constant re-examination

# DISLOCATION AND FRACTURE-DISLOCATION OF THE PELVIS

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*Paper read at the combined meeting of American, Canadian, and British Orthopaedic Associations in Quebec June 1948*

This paper is based upon a study of fifty cases of disruption of the pelvic ring. The cases occurred during the years 1937 to 1946 in the Accident Department of the Sheffield Royal Infirmary and its associated hospitals.

**Two types of disruption of the pelvic ring**—The injury occurs in two varieties: 1) dislocation of the sacro-iliac joint, 2) fracture of the ilium or sacrum adjacent to the sacro-iliac joint. In both types there is separation of the symphysis pubis, or fracture of both pubic rami. In both varieties there is displacement of one-half of the pelvis outwards, or outwards and upwards. Associated with this displacement there is often rotation of the large pelvic fragment in the sagittal plane (Figs 4 and 6). This injury occurs with some frequency and it is surprising that only a few series have been reported in the literature. Most reports are confined to isolated cases, to particular methods of reduction, or to visceral complications of the lesion, and it is for this reason that a complete follow-up of a comparatively large series may be of interest.

## MECHANISM OF INJURY AND DISPLACEMENT

Taylor (1942) reported twenty-two cases of dislocation of the symphysis pubis, or hind-quarter dislocation, and was of opinion that the injury was sustained by indirect violence, the leg acting as a long lever dislocating the pelvis. Most authors, however, consider the lesion to be the result of direct violence—a view which is strongly supported by this series. In all cases there was severe direct violence, either an antero-posterior crush, or a torsional injury where the sacrum was fixed and one-half of the pelvis was forced back by direct antero-posterior violence to one ilium. For instance, in Case 42 (Fig 4) a woman was run over by a heavy motor-car, the wheel passing over the front of the pelvis, resulting in complete disruption of the pubis and the sacro-iliac joint. In Case 30, a steel erector, aged twenty-seven years, was standing on a girder with his sacrum against a vertical post, when the cage of a travelling crane moved back and struck his right ilium. He sustained separation of the pubis and fracture through the ilium.

Pubic injury with sacro-iliac dislocation is more common than pubic injury with fracture of the ilium or sacrum. Of the forty-two patients in this series who survived and were traced, there was sacro-iliac dislocation in twenty-seven, and fracture of the ilium or sacrum near the joint in fifteen. Both injuries, however, result in the same type of displacement. The pubic bones are separated and the pelvis is opened out at the posterior injury "like the leaves of a book" (Watson-Jones 1938). Associated with the outward rotation there is often upward displacement of the injured side and sometimes rotation (Fig 6).

**Visceral injuries and retroperitoneal haemorrhage**—Most authors emphasize the severity and danger of visceral complications, particularly lesions of the bladder and urethra. These, however, appear to be rare. In this series, only four cases of injury to the bladder or urethra occurred. Two had large extra-peritoneal tears in the bladder and both died. Two had tears of the urethra and survived. No other visceral complications occurred. The most frequent complication was retroperitoneal haemorrhage, severe enough to be alarming, and in four cases causing death. The bleeding probably arises from tearing of the

ilio-lumbar artery, and it tracks forward towards the anterior superior spine. When severe it may cause an alarming fall of blood-pressure. There appears to be no possibility of controlling the haemorrhage by surgery or pressure, the best treatment is to maintain the blood-pressure at not more than 100 mm of mercury by controlled transfusion, until the bleeding ceases. Bleeding severe enough to cause alarm has occurred in eight patients, four of whom died.

### REDUCTION AND IMMOBILISATION

The method of reducing the deformity and maintaining the position should be determined by proper recognition of the displacement. Outward rotation of the large fragment of the pelvis is maintained by the outward roll of the leg and extension of the hip (Fig 1). Many methods of reduction have been described, most of which do not recognise the importance of the position of the legs. Two methods only are really rational—the method of lateral recumbency and plaster of Watson-Jones (1938, 1943) and the sling method originated by

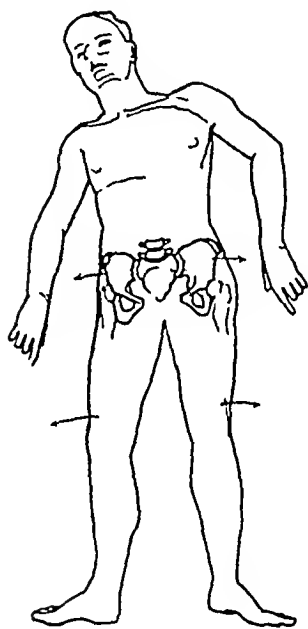


FIG 1

The pelvic dislocation is opened out anteriorly by extension at the hip joint and by outward rolling of the lower limbs.

Astley Cooper (1842) and developed by Bohler (1935). Lateral recumbency and plaster is theoretically sound but difficult in practice and, in this series, the sling method has been used exclusively (Figs 2 and 3). The method is simple, safe, and efficient. The patient is placed upon a bed with fracture boards and an overhead frame, a firm canvas sling, spread by rods, is placed under the pelvis. The sling extends from above the iliac crest to below the greater trochanters. The rods are attached to cords which pass over pulleys in the overhead frame, the cords from the left side crossing over to the pulleys on the right and vice versa. The ends are attached to weights, the total of all four weights being sufficient just to raise the patient from the bed. Each leg is then placed upon a firmly bandaged Braun's frame, so that the hips are flexed. The limbs are kept in this position by weight extensions of eight pounds, attached by strapping extensions. The patient is then supported on a back rest. If, in addition to separation of the pelvic halves, there is upward displacement of one half, skeletal traction is applied to the limb of the affected side with sufficient weight to pull the fragment into position. Frequently no anaesthetic is required for this procedure but, if rotational displacement of the fragment is also present, then manipulation is necessary. The patient is anaesthetised, placed upon the sling and turned on his side.

The rotated fragment is pushed forwards, the patient is then rolled on his back and the sling and frames are adjusted.

The degree of compression by the pelvic sling can be adjusted by altering the obliquity of the ropes. Control radiographs are taken and the ropes are adjusted so that the pubic symphysis is kept in position. Reduction is usually complete and the position can be maintained with little difficulty (Figs 4-7). Nursing in the apparatus is easy. The patient can be lifted for the use of bed-pans by pulling on the weights and, if the lower end of the sling is turned back, the bed-pan can easily be slid into place. Most patients are quite comfortable in the apparatus, though in the very old there may be some mental confusion in the early stages of treatment.

Fixation is maintained for twelve weeks but, after six weeks, the traction weights are removed and graduated leg exercises are allowed. Weight-bearing and active rehabilitation is started after twelve weeks.

## ASSESSMENT OF END-RESULTS

The ultimate object of treatment of every injury is full restoration of function. Restoration of the anatomical position in any fracture is easy to assess and may or may not be important, but function is all important and, as Nicol has pointed out "The assessment

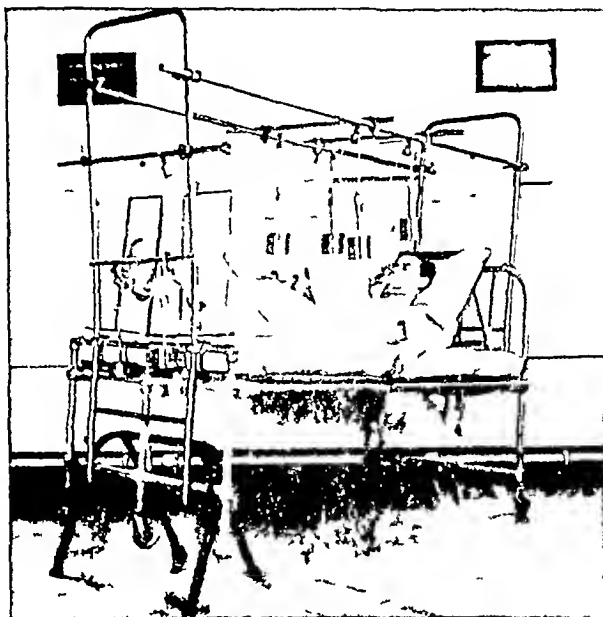


FIG 2



FIG 3

Fracture dislocation of the pelvis immobilised in sling and frames with skeletal traction applied to the left leg

of function is based upon criteria which vary from one surgeon to another and are subject to individual judgment rather than precise measurement." Therefore, following his lead, capacity for work has been used in this investigation as the criterion of recovery of function. Most patients were engaged at the time of accident in heavy industrial activity so that return



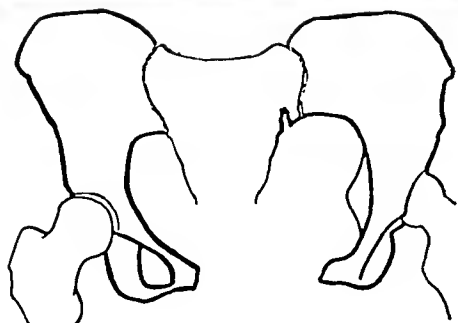


FIG 4

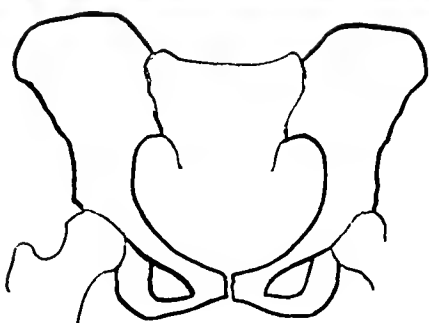


FIG 5

Gross separation of one half of the pelvis with wide separation of the symphysis and dislocation of one sacro iliac joint (Fig 4) Same case after reduction by the pelvic sling (Fig 5)

to pre-accident work, or similar heavy work such as labouring, joinering, or bricklaying, formed a reasonable standard of full recovery. In women the ability to perform all household work has been considered heavy work. The average period of follow-up after accident is five years and no case has been assessed less than two years after the accident.

On the whole the end-results are good. It will be seen from Table I that the prognosis in dislocations of the sacro-iliac joint is not so good as in the case of fractures near the joint. About half the cases of sacro-iliac dislocation were able to return to reasonably heavy work but nearly all cases of fracture were able to do so. All patients complained of pain in the pubis, sometimes lasting as long as two years but eventually disappearing. Even in the best cases there was often aching in the back after prolonged effort. In sacro-iliac dislocations

TABLE I  
DISLOCATIONS AND FRACTURE-DISLOCATIONS OF THE PELVIS

Total number of cases	50		
Died	6		
Untraced	2		
Complications—			
Rupture of the bladder	2	Died	2
Rupture of the urethra	2	Died	0
Retroperitoneal haemorrhage	8	Died	4
End result in forty-two traced cases—			
Fracture or dislocation of pubis with	Total	At heavy work	Painful
1) Dislocation of sacro iliac joint	27	12	15
2) Fracture of ilium or sacrum	15	13	2



FIG 6



FIG 7

Fracture dislocation of the pelvis with double pubic fracture and fracture of the ilium near the sacro-iliac joint (Fig 6) Same case after reduction by the pubic sling (Fig 7)

this pain was severe, it was localised to the joint and it prevented the patient from performing anything but the lightest of work. All patients who were free from pain showed a full range of spine and hip movements with complete pelvic stability and no limitation of straight leg raising. In the case of patients who had pain, spinal movements were good but there was definite limitation of straight leg raising on the affected side, which was often very marked.

These figures appear to be significant. The frequency of persistent sacro-iliac pain after dislocation of the joint suggests that early sacro-iliac fusion should be considered in such cases. Certainly it appears to be indicated in patients with severe localised pain persisting for one to two years after injury. The pain in such cases is probably due to unsound ankylosis of the sacro-iliac joint. The strong anterior ligaments are torn from the front of the sacrum and ilium and the remnants may curl within the joint, preventing true restoration of position. Whatever the cause, however, there is no doubt about the residual pain and its localisation to the joint, and fusion seems to offer the best prospect of relief.

#### SUMMARY AND CONCLUSIONS

- 1 Fifty dislocations and fracture-dislocations of the pelvis have been reviewed
- 2 Complications were unusual. Two patients with rupture of the bladder died, two with rupture of the urethra survived. Of eight patients with retroperitoneal haemorrhage four died, the treatment advised is controlled blood transfusion maintaining a blood-pressure of not more than 100 mm.
- 3 Two types of pelvic disruption should be distinguished: 1) pubic injury with sacro-iliac dislocation, 2) pubic injury with fracture near the sacro-iliac joint. The first is twice as common as the second.

4 In each type, displacement is maintained by extension of the hip and outward roll of the limb. This may be controlled by the Watson-Jones plaster method but the pelvic sling technique is preferred and was used in all cases in this series.

5 The prognosis in fracture-dislocations is very good, nearly all patients went back to heavy work.

6 The prognosis in sacro-iliac dislocations is not so good, only half the patients went back to heavy work and there was often persistent sacro-iliac pain. Sacro-iliac arthrodesis is advised in those cases.

#### DISCUSSION

Dr H. Earle Conwell (Birmingham, Ala.) Mr Holdsworth has presented an excellent series of radiographs and sketches showing the various locations of dislocation and fracture-dislocation of the pelvis, especially those about the sacro-iliac joint. I would point out that in 1930 and 1933, Noland and I reported in the Journal of the American Medical Association and in Surgery, Gynecology and Obstetrics 183 fractures of the pelvis observed over a period of eleven years in which there were fifty dislocations of the sacro-iliac joint. Since that time I have observed over a period of fifteen years 240 cases of fractures of the pelvis in which there was about the same percentage of dislocations and fracture-dislocations of this type.

Such injuries are in most instances of a severe nature and contrary to Mr Holdsworth's observation I have found a far greater proportion of soft tissue complications involving the bladder and urethra, retro-peritoneal hemorrhage and intra-abdominal involvement, which demanded immediate general surgical as well as orthopaedic consultation.

The plaster cast treatment with its various techniques of which there is more than one has been generally discarded in the States. The pelvic sling, with traction to the lower extremities has been my choice of treatment for over a quarter of a century. After reduction has been carried out (a general anæsthetic being preferred) skeletal traction is applied through the lower end of the femur on the injured side with simple adhesive traction on the uninjured side supplemented by the pelvic sling.

Function is the criterion of a good result and reduction of these fractures and dislocations is not always necessary to bring about good function. Reduction should not be carried out forcibly to the sacrifice of the patient's general condition.

Arthrodesis is probably indicated in very few cases. It is difficult to make this decision until the patient has progressed sufficiently in convalescence. Moreover it has been my experience that patients with persistent pain over the sacro-iliac areas also have complications in the low spine and that if arthrodesis is necessary it should include the lumbo-sacral as well as the sacro-iliac joint. I do feel that a simple back support during convalescence is of much value in relieving pain. Conservatism is indicated in most cases. Mr Holdsworth is to be commended for bringing this subject before us.

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# CAUSALGIA

## Diagnosis and Treatment

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This paper is based on a study of twenty-four patients in whom the major symptom was persistent pain after injury to one or more peripheral nerves. It is sometimes a matter of difficulty to distinguish the persistent pain of true causalgia from the pain of other post-traumatic conditions, particularly since few clinicians have the opportunity of studying large series of such cases. Paget (1864) and Weir Mitchell (1872) gave classical descriptions, but it was not till the first Great War that any extensive series was reported. In a publication of the Medical Research Council (1920) the pain was described as being spontaneous in onset, hot and burning in character, intense, diffuse, persistent, and subject to exacerbation, excited by stimulation which did not necessarily produce physical effect on the limb, usually aggravated by emotional excitement which brought on a paroxysm, and responsible for profound changes in the emotional state of the patient. More recently it has been suggested that another characteristic of the pain is that it is relieved by sympathetic block (Doupe, Cullen, and Chance 1944).

In the group of cases now reported these descriptions appear to be much too rigid. Whereas all patients agree that the onset of pain is spontaneous, the quality is variable and often bizarre. One patient described it as severe and burning during the first six weeks, later changing to intense "shooting pain like toothache". Others, in describing it, made use of such expressions as "trickling pieces of broken glass", "skin tightly stretched over a bone", "crushed as in a vice", and "nails being torn off the fingers". In five patients pain began on the day of injury. In the others it was first observed at varying periods up to forty days after injury. These figures, however, are uncertain, because many of the victims were unconscious for a period, or were subject to the strain of long evacuation from dangerous areas while in very poor general state.

### CLINICAL FEATURES OF CAUSALGIA

*The site of pain* is well defined in some cases. Two patients described it as limited to the outer three and a half fingers, one referred it to the ring finger alone. Persistent pain is usually situated in the foot or hand. In four cases only was there spread to the forearm or leg. It may be felt superficially, but not infrequently it involves the deeper tissues and even the bones.

*Factors precipitating pain*—Patients are in general agreement as to the factors which precipitate pain, namely loud noises, sudden jarring of the bed, psychical causes such as seeing other patients slip or fall, and excitement associated with the watching of thrilling pictures. Overheating and intense cold both cause severe pain, as does dry contact with any part of the body. It is relieved by moist cloths, usually applied to the affected limb and occasionally to another limb. Weir Mitchell refers to patients who filled their boots with water in order to gain relief.

*Sympathetic block*—Blocking the stellate ganglion with novocaine often gives valuable information despite the fact that the test is largely subjective and that it is dependent upon the interpretation of the patient. When there is injury of the median or internal popliteal nerves, relief is immediate and complete for the duration of the injection. It is usually volunteered that the pain has gone, that the limb can be handled, and that the patient is no longer under the domination of loud noises and other stimuli.

Of seventeen patients who had sympathetic block on one or more occasions, thirteen were immediately relieved. One was distressed by the injection, and interpretation of the result was vitiated by his general condition. Three others were incompletely relieved, and it is noteworthy that in these cases the lesion was a complete tear of the brachial plexus at the level of the roots. It is possible that in such circumstances a more extensive block is indicated, including the middle and superior cervical ganglia, or the thoracic ganglia as low as the sixth (Leriche 1939).

After a trial of anterior approach to the ganglion this method was abandoned because 1) it is uncertain in its results, 2) it is painful, 3) the lower cord of the plexus is likely to be involved, 4) the patient is more aware of the surgeon's activities when he works from the front—a very real objection in the case of individuals who are liable to emotional disturbance, 5) the vessels may be damaged.

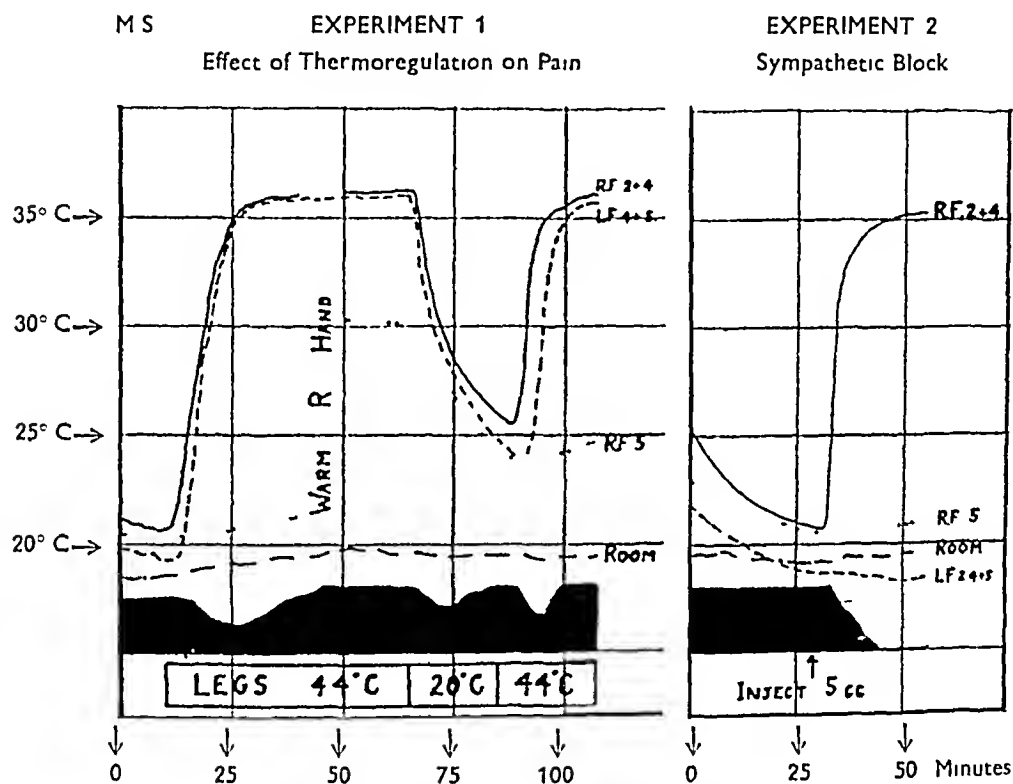


FIG. 1

Case 22 Median and ulnar nerve lesion right hand with causalgic pain in the tips of the fingers. Temperature records of the fingers of both hands show that the right fifth finger (RF 5) was persistently cold despite alterations in room temperature and even despite sympathetic block.

*Technique of sympathetic block—upper limb*—The patient sits astride a chair with the fore arms supported so that the shoulders droop. After anaesthetising the skin, two Pitkin needles, without stylettes, are introduced one and a half inches lateral to the spinous processes of the first and second thoracic vertebrae, they are directed medially at an angle of forty-five degrees to the sagittal plane so as to hit the first and second ribs. The needles slip under the ribs and are felt to perforate the intercostal membrane. The points are then in the extra-pleural space in front of the necks of the ribs. Three or four cubic centimetres of 2 per cent novocaine are introduced into the loose areolar tissue outside the pleura. If the needles are correctly placed Horner's syndrome appears within a few minutes, the skin of the arm becomes dry.

*Technique of sympathetic block—lower limb*—This is a more difficult and uncertain procedure. The classical method of paravertebral block is used, according to the technique of Kappi. Two needles are introduced through intradermal wheals, seven centimetres lateral to the first and second lumbar spines. They are directed medially, at an angle of forty-five degrees to the sagittal plane, until they strike the sides of the vertebral bodies. Each needle is then withdrawn slightly and manipulated past the side of the body for a distance of one to two centimetres. Five to ten cubic centimetres of novocaine are injected. Loss of sweating of the limb is a reliable test of a successful block.

**Objective findings**—The objective findings have been described accurately on many occasions (Paget 1864, Weir Mitchell 1872, Leriche 1939, etc.) The glossy skin, spindle fingers, and clawed stained nails are well recognised. Macerated skin and the bullous lesions which are sometimes encountered are the result of reluctance to allow frequent cleansing,

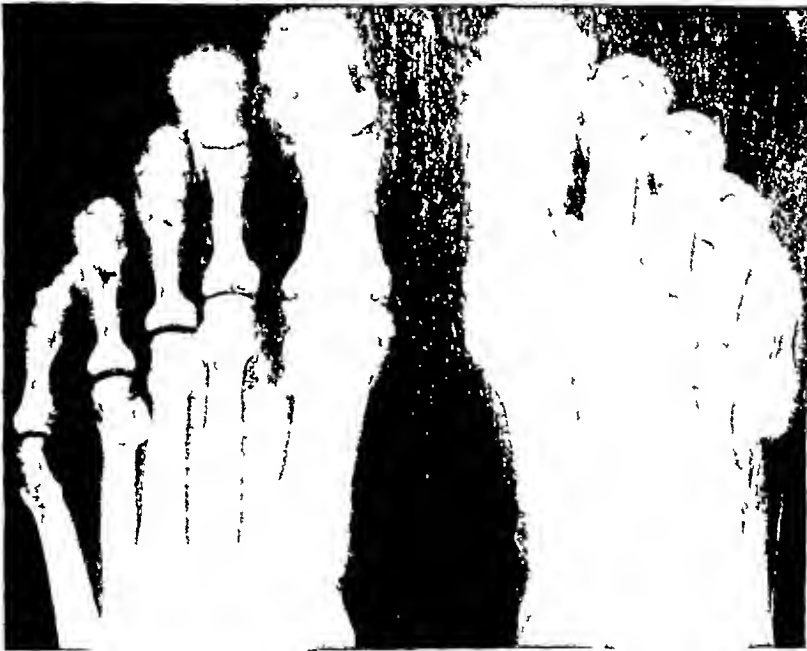


FIG 2

Case 3 Internal and external popliteal nerve lesion with causalgia of foot  
Severe glassy atrophy in the causalgic limb twelve months after injury  
The normal foot is on the left

or the constant use by the patient of moist applications. Hyperhydrosis is not a constant feature and has often been noted when there are nerve lesions without pain. Vascular dilatation is not always present. In the patients of this series the temperature of the limb was colder than normal in three, variable in five, warmer than normal in thirteen, and normal in one, in two there was no record. These variations are probably related to local conditions of temperature, or they are referable to the time and degree of coincident nerve injury. Severe vascular damage is not always associated with a cold limb. (Vascular changes after nerve injury, local trauma, and sympathectomy have been studied extensively by Lewis and Pickering 1931, and Doupe *et al* 1944.) During the first three weeks after injury the blood flow in the digits is increased, but at a later stage it returns to normal, or there may even be vasoconstriction due to sensitisation of the vessels to adrenaline (Freeman, Smithwick, and White 1934).

*Bone changes* are not specific. They may take the form of true Sudeck's atrophy or they may be of the more generalised glassy type (Fig 2). The former variety tends to merge into

the latter as weeks go by. These changes have been recorded in patients without pain. Conversely, in one patient with relatively severe pain, they were minimal.



FIG 3  
One month



FIG 4  
Two months



FIG 5  
Six months



FIG 6  
Twenty-four months

Case 6. Median ulnar and radial nerve lesions with causalgia of the hand. Radiographs of the hand at various intervals after injury showing the development of bone changes.

*Psychical assessment* of patients who are in great pain is difficult but, in this series, examination was undertaken and an opinion expressed at a time when pain was not severe. Two patients were definitely abnormal, one was aggressive and impulsive, and one had a mild anxiety state. The inference which was drawn was that one was highly strung and the other of low intelligence. Too much attention has formerly been paid to personality changes. They are the result of pain. Once the pain is relieved they disappear.

*Nerves involved*—In this series of twenty-four cases the median nerve was involved in fifteen (median nerve alone, two, median and ulnar nerves, six, median, ulnar, and radial nerves,



Case 3 External popliteal nerve lesion (left) with causalgia of the outer side of the foot



Case 6 Right median ulnar and radial nerve lesions with causalgia of hand

Case 1 Right median and ulnar nerve lesion with causalgia of fingers and thumb

FIG 7

Sweat tests in three cases of nerve lesions with causalgia showing anhydrosis in the distribution of the affected nerves marked soft tissue atrophy and contractures

four, median and internal cutaneous nerves, one, median, radial, and musculo-cutaneous nerves, one, median, ulnar, radial, and internal cutaneous nerves, one) There was supra-clavicular injury to the brachial plexus in four cases Nerves of the lower limb were involved in five cases (internal and external popliteal nerves, four posterior tibial nerve, one)

*Cause of nerve injury*—In twenty-one patients the injury was due to high velocity projectiles, in three the injury was a traction lesion of the brachial plexus It is of interest to



note that the two nerves, injury of which is most likely to give rise to causalgia, carry in close proximity or actually in their substance the old axillary artery of the limb, and that they have a high proportion of non-medullated nerve fibres (Leriche 1939)

*Site of nerve injury*—In upper limb cases the site of injury was supraclavicular, four, axilla and upper third of the arm, thirteen, mid-third of the arm, one, lower third of the arm and elbow, one. In lower limb cases the site of injury was buttock, two, upper third of the thigh, one, mid third of the thigh, one, and calf and ankle, one. In only two patients was the injury situated in the peripheral part of the limb (Cases 10 and 17, Table I). In these the pain was atypical, being actuated more by physical than by emotional factors, and being intermittent rather than continuous. Similarly, in patients with brachial plexus lesions, considerable periods of freedom from pain are usual and the common precipitating factors do not always initiate a paroxysm.

*Vascular injury*—In the upper limb most cases were associated with lesions at the level of the anterior axillary fold and the upper third of the arm and they were associated not infrequently with major vascular damage. Arterial injury was proved at operation in eight cases: there was arterial injury requiring ligation in three cases, and venectomy was necessary in one case. In the lower limb, vascular damage was unusual. In only one patient was vascular deficiency, as determined by clinical estimation, of severe degree.

*Bone injury and infection*—Coincident infection and bone injury appeared to play little part in the syndrome. Three of the most severe cases had relatively superficial wounds which healed rapidly, patients with fractures showed no relief when the bones united, and patients with moderate sepsis did not improve when the infection became quiescent.

### TREATMENT OF CAUSALGIA

Every case of severe causalgia calls urgently for treatment, not only to relieve pain and suffering but also to prevent crippling deformities, especially in the hand, which result from voluntary immobilisation for a long period. Weir Mitchell (1872) reported success after blistering. The injection of novocaine and alcohol has been used with doubtful results. Two patients in this series noticed relief after an attack of malaria. This prompted a trial of artificial pyrexia, which, however, was abandoned as worthless after using it in three cases.

*Neurolysis*—Resection, suture, and neurolysis have been reported upon favourably by Platt (1921). In this series neurolysis was performed on nine occasions. In every case slight relief was obtained for a short period. Unfortunately, however, the maximal period of relief was no more than three weeks. Leriche (1939) favoured peri-arterial sympathectomy and arterectomy. These operations were performed in this series on five occasions without permanent benefit.

*Radiotherapy*—Eleven patients were treated by radiotherapy. Interpretation of the results was difficult, largely because the treatment was experimental and because it was applied only in cases which were thought to be unsuitable for sympathectomy.

*Technique*—The technique used was that recommended by Mumford (1938). One hundred and fifty "r" units were given with a superficial therapy tube at 70 K V once weekly for four weeks. In a few patients this treatment was repeated after a short interval, and in two patients a single dose of 800 "r" units was also given directly to the site of the nerve lesion. It is of interest to note that when there was relief it occurred approximately at the time that an X-ray reaction would be expected—about three weeks after exposure.

Of the eleven patients so treated, four subsequently required sympathectomy. Of the other seven patients, six were convinced that improvement began two or three weeks after treatment and that it was progressive after that date. The improvement was both subjective

and objective. Pain was relieved and the general appearance of the hand was improved, it could be handled without severe lancinating pain. One patient was not improved and has since had a tractotomy.

Three patients who gained relief were suffering from traction lesions of the brachial plexus. This is a point of considerable importance since in this group of patients relief by sympathetic block is by no means the rule, and neurectomy, tractotomy, and radicotomy have not solved the problem (Leriche 1939).

**Illustrative Case No. 8** (Tables I and II)—Three days before admission was accidentally shot through the right axilla. Immediate operation disclosed that the axillary vein was divided; it was ligatured. The artery was intact. The condition of the nerves was not determined. On admission he complained of throbbing pain in the wound. There appeared to be a complete block of the median, ulnar, and musculospiral nerves. One week after injury he began to have aching pain down the ulnar side of the forearm extending into the palm of the hand. This was fairly constant but at times it disappeared for a few minutes. It was so severe as to prevent more than two or three hours sleep. The pain disappeared in the course of two or three weeks. Six weeks after injury sensation began to return to the median and musculospiral areas, with concomitant return of muscle power. No function was regained in the distribution of the ulnar nerve. At this time the patient began to complain of burning searing pain in the part of the hand to which sensation had returned. This was very severe and its depressing effect was apparent on the face of the patient which became haggard and careworn. The pain was aggravated by any attempt to move the hand or wrist and by even the lightest touch over the median nerve. It was relieved when the patient avoided excitement and kept as quiet as possible. When asked about the cinema he reported that he had to close his eyes during action scenes in order to lessen the pain. There was slight hyperhidrosis of the hand in the area of distribution of the median nerve and because of the fixed position the skin was macerated and did not present the appearance of 'glossy fingers'. There was oedema and limitation of movement at all joints. Radiographs showed evidence of Sudeck's atrophy.

At the third month after injury there being no sign of improvement in pain nor return of function to the ulnar nerve the brachial plexus was explored by Mr Roland Barnes. The median nerve appeared normal and was involved only in the thinnest scar tissue. The ulnar nerve was found to be divided; it required suture. The axillary vein was represented by a fibrosed cord. The axillary artery appeared normal. Peri-arterial sympathectomy was performed by stripping the adventitia from the vessel over a distance of five centimetres. After operation pain was partly relieved for about one week. It then returned to its former intensity still being felt only in the median area.

The sympathetic chain was blocked twice in the fifth month with good but only temporary relief. Block of the median nerve at the level of the wrist abolished all pain in the hand.

In the sixth month radiotherapy was given to the hand and about seven to ten days later he began to improve. In the next two weeks further improvement occurred so that although not free from pain he looked less careworn; the limb could be handled much more freely. Improvement thereafter was continuous though slow. There was much pain on attempting to move the stiff joints. After twelve months he was sufficiently recovered to be able to return to work as a shoemaker but emotional excitement still caused some pain. When last seen at the twenty-fourth month all muscles innervated by the ulnar nerve were contracting; there was only a vestige of pain; joint movement was still limited; radiographs showed recalcification of the porotic bones.

**Sympathectomy**—Sympathectomy was performed in eight patients—lumbar ganglionectomy in two, and stellate ganglionectomy in six. In the two patients with causalgia of the lower limb relief was complete after excision of the third and fourth lumbar ganglia. The stellate ganglion was excised by the anterior approach in six patients. Pain was completely relieved in five. One patient continued to complain of burning pain in the ring finger, but the rest of the hand was free of pain.

The advantages of the White and Smithwick operation are recognised, but stellate ganglionectomy is preferred. The objection to removing the ganglion in vascular disorders is in large part due to the late sensitisation of small vessels in the limb and to early regeneration of the sympathetic fibres. This objection does not hold in causalgia when the only desideratum is relief of pain. Horner's syndrome is not a serious disability and few patients complain of it. In an early case, the second and third dorsal ganglia were decentralised from

TABLE I—CLINICAL FEATURES OF TWENTY-FOUR CASES OF CAUSALGIA

Case No	Nerves involved (See Note 1)	Site of injury	Time of onset of pain	Distribution	Main vessels	Temperature of hand or foot
1	Median Ulnar	Axilla	1 month	All fingers and thumb	Artery thrombosed	Colder
2	Median Ulnar*	Axilla	1 day	Median area of hand	Artery lacerated (ligated)	Colder
4	Median	Axilla	2 weeks	Hand (vague)	No injury	Warmer
5	Median Ulnar Radial	Upper third arm	1 day	Palm fingers and nails	No evidence of injury	Warmer
6	Median Ulnar Radial	Upper third arm	1 day	Tip of thumb index and middle fingers median area palm	No record	Warmer
8	Median Ulnar Radial Int cutaneous	Axilla	20 days	Palm second third and fourth fingers	Artery intact vein ligated	Warmer
10	Median Int cutaneous	Elbow	1 hour	All fingers hand forearm	No injury	Equal
12	Median Radial Musculo cutaneous	Axilla	5 days	Outer three and a half fingers hand elbow	No record	Warmer
13	Median Ulnar* Radial*	Axilla	7 weeks	Palm and fingers	Artery ruptured (ligated)	Warmer
14	Median Ulnar	Axilla	2	Median area of palm	Artery ruptured (sealed by clot)	Warmer
18	Median	Mid third arm	2 days	Middle and ring fingers palm	Artery ruptured	Warmer
19	Median Ulnar Radial	Ant axillary fold	4 days	Centre of palm and metacarpals	Artery ruptured (ligated)	Normal or Warmer
21	Median Ulnar	Ant axillary fold	1 day	All fingers and palm	Thrombosis of brachial artery	Variable
22	Median Ulnar*	Ant axillary fold	7 days	Tips of fingers	No record	Variable
24	Median Ulnar	Upper third arm	1 month	Palm and fingers	Rupture of artery?	Warmer
11	Brachial plexus*	Supraclavicular	3 weeks	Hand and fingers	No definite injury	Variable
16	Brachial plexus*	Supraclavicular	3 weeks	Hand and fingers	No definite injury	No record
20	Brachial plexus*	Supraclavicular	11 days	Hand and fingers	No definite injury	Variable
23	Brachial plexus (Upper cord)	Supraclavicular	24 hours	Hand (palmar surface)	No definite injury	Warmer
3	Int popliteal Ext popliteal*	Upper third thigh	3 days	Sole of foot (outer side)	No injury	Warmer
7	Ext popliteal Int popliteal	Mid third thigh	7 days	Sole of foot	No injury	Colder
9	Ext popliteal Int popliteal	Buttock	4 days	Heels and sole	No injury	Warmer
15	Ext popliteal Int popliteal	Buttock	25 days	Foot	No injury	Variable
17	Post tibial*	Ankle	4-5 weeks	Sole	No obvious injury	No record

Note 1—Complete nerve lesions are marked thus \* All others were incomplete

TABLE II—TREATMENT AND RESULTS IN TWENTY FOUR CASES OF CAUSALGIA

Case No	Novocaine block of sympathetic (see Note 1)	Result of treatment by			Follow-up	
		Neurolysis (see Note 2)	Radiotherapy	Sympathectomy	One year	Two years
1	Temporary relief (few hours)	Temporary relief (four days)	Gained relief after three weeks	—	Improved	Further improvement (working)
2	—	No immediate change	—	—	Slow improvement	Further improvement
4	—	No relief	—	Complete relief	Free of all pain	No pain
5	—	Treated by physiotherapy alone (improved)			Improved	Further improvement (drives a bus)
6	Relief duration of injection only	—	No relief	Complete relief	Free of all pain	No pain
8	—	Temporary relief (seven days)	Gained relief after three weeks	—	Improved	Steady improvement
10	Temporary relief (few hours)	Temporary relief (few days)	—	—	No permanent benefit	I S Q
12	Relief duration of injection only	—	—	Complete relief	Hand aches when cold	Almost complete relief
13	Relief duration of injection only	—	—	Almost complete relief	Hand aches when cold	Relief almost complete
14	Relief duration of injection only	—	—	—	Hand aches when very hot or cold	I S Q
18	Temporary relief	—	Improved	—	Free of pain	No pain
19	Temporary relief	—	Improved after three weeks	—	Much improved	Further improvement
21	Temporary relief	—	Not much relief	Immediate relief	No pain	No pain
22	Temporary relief	Temporary relief (three days)	Not much relief	Marked immediate relief	Pain in ring finger	I S Q
24	Temporary relief	Temporary relief	—	—	No permanent benefit	
11	Relief duration of injection only	—	Improved	—	Still some pain	Still some pain
16	No relief	—	Not much change	—	Improved	Has had tractotomy
20	Temporary relief	—	Not much relief	—	Improved	I S Q
23	No relief	Treated by physiotherapy (improved)			Much improved	Almost free of pain
3	Slight temporary relief	—	Not relieved	Complete relief	Free of pain	No pain
7	—	Treated by physiotherapy alone (slow improvement)			Pain less	Further improvement
9	Temporary relief (few hours)	—	—	Immediate relief	Foot tender on deep pressure	No pain
15	—	Treated by physiotherapy alone (relieved)			Free of pain	Free of pain
17	—	Alcohol injection at site of injuries (2 ccs)			Improved	Untraced

Note 1—Novocaine 2 per cent was used. In Cases 1, 3, 12 and 13 there were two injections and in Case 19 three injections.

Note 2—Arterectomy was combined with neurolysis in Cases 1 and 2. Periarterial sympathectomy was combined with neurolysis in Cases 8, 10 and 24.

behind. After two or three days, pain reappeared in its original intensity. At subsequent operation the neck of the rib was exposed from in front. This necessitated positive pressure anaesthesia, because the pleura was adherent and friable. The stellate ganglion, and a small filament which joined the first root from below, were excised. After this operation the patient was relieved of all pain and has remained so for over three years. In a second patient, Horner's syndrome did not develop after operation, proving that the stellate ganglion or aberrant sympathetic fibres had not been excised completely. This man continues to complain of pain in his ring finger although the rest of the hand is now painless.

Experience of these two cases suggests that when complete sympathectomy is essential this is best achieved by the anterior approach with resection of the stellate and second ganglia and any adherent fibres which are visualised. If there is difficulty, positive pressure anaesthesia should be used with incision of the pleura.

**Illustrative Case No. 13** (Tables I and II).—Admitted four months after receiving shell-wounds of the left shoulder and antecubital space causing compound fracture of the humerus with apparent palsy of the ulnar and median nerves. One month later, after remanipulation of the left humerus, he noticed severe pain in the left hand. He described the pain as terrific, but could not specify its quality. It was aggravated by smoking, by the noise of aeroplanes, by wireless and by jarring his bed. He lay in bed with knees drawn up and complained of severe exacerbation when they were straightened. Stroking the feet or other contact made the pain almost unbearable. He was irritable, solitary and always depressed. His manner was almost cringing. The pain was felt diffusely on the palmar aspect of the hand including the aesthetic area. It had progressed steadily since the injury. Analgesic drugs even in large doses failed to give relief. Morphine alone gave a few hours sleep. Some relief could be gained by holding a cold wet cloth in the hand of the uninjured limb.

The arm and forearm were oedematous. Light touch increased the pain. The fingers and wrist were so stiff as to appear ankylosed. The skin on the dorsum of the hand and fingers was thin and shiny; on the palmar surface it was encrusted and macerated.

In so far as clinical examination was possible, it was evident that the patient had a complete ulnar and musculospiral palsy. There was diminished appreciation of light touch and pin-prick in the median area with paralysis of the thenar muscles, but there was still some contraction of the long finger flexors supplied by the median nerve.

At the fifth month stellate block with 2 per cent procaine gave almost complete though temporary relief of pain. The condition of the wounds made it necessary to defer operation until the seventh month. Stellate ganglionectomy was then performed. After this the patient had complete relief from his terrific pain; there remained only slight aching in the palm which the patient attributed to stiffness. The limb could then be handled without causing pain; other stimuli caused no ill effect. He could smoke without pain and he was able to discard his damp rag. When in conversation he smiled and in fact he became a normal person. The fingers were, of course, still stiff, but it became possible to initiate treatment.

### ANALYSIS OF THE RESULTS OF TREATMENT

**Novocaine injection into ganglia.**—Twenty-three novocaine injections were performed in seventeen patients. Of these, eight were treated subsequently by sympathectomy and nine by radiotherapy. No permanent benefit from novocaine injection was observed.

**Sympathectomy.**—After sympathectomy, seven patients were relieved of all pain at the end of one year, one complained of occasional pain in the ring finger. The marked improvement in these patients was maintained for two years after operation.

**Radiotherapy.**—Radiotherapy alone was used in seven patients, three with brachial plexus lesions and four with median and other peripheral nerve lesions.

**Brachial plexus.**—Two patients were almost free from pain after two years and suffered pain only on excitement or exposure to cold. One showed no definite improvement and has since been treated by tractotomy.

**Median and other nerves.**—In all four patients there was steady improvement over two years. It is noteworthy that the quality of result was less satisfactory than that obtained after

sympathectomy While these patients were able to carry on with their work (the only limiting factors being due to the physical defect caused by the nerve injury) they were still liable to mild recurrences of pain as the result of excitement, loud noises, or exposure to cold

**Other forms of treatment**—The other nine patients included one who had alcohol injection with incomplete relief, three who were treated by neurolysis with peri-arterial sympathectomy in two, and arterectomy in one only one showing slow improvement over two years which did not appear to be related to the operation, and four mild cases who had simple physiotherapy including wax baths, galvanism, and massage Physiotherapeutic treatment is not of course tolerated in severe cases It is of value only for the correction of stiffness or contracture after pain has been relieved by specific treatment These patients who had no specific therapy showed, with the passage of time, varying degrees of improvement While not altogether free from pain, they are not incapacitated seriously

### SUMMARY

- 1 Twenty-four patients complaining of severe pain after nerve injuries have been considered from a diagnostic and therapeutic point of view
- 2 The typical syndrome of causalgia develops only when the median or internal popliteal nerves are injured It is doubtful whether pain associated with injury in the peripheral part of the limb, or of the brachial plexus, should be classed as causalgia
- 3 The importance of novocaine block of the sympathetic ganglia as a diagnostic test is stressed, and its usefulness as a therapeutic measure is considered
- 4 Sympathectomy is shown to be a reliable method of treatment in suitable cases
- 5 The limited field of application of radiotherapy is also indicated

I wish to thank Dr J Doupe for the loan of Plate No 1 and Dr G Q Chance for the loan of radiographs and his help in arranging radiotherapy I am also indebted to the Medical Photographic Department of the Manchester Royal Infirmary for the prints of radiographs

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# POSITIVE PRESSURE IN ARTHRODESIS OF THE KNEE JOINT

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*Based on Cases presented at the British Orthopaedic Association Meeting in Manchester, October 1947 and a Paper read at the meeting of the American, British and Canadian Orthopaedic Associations in Quebec June 1948*

Albert Key (1932) described a method of arthrodesis of the tuberculous knee joint in which the cut bone surfaces were compressed against each other after excision of the joint. He had previously been impressed with the difficulty of securing bone union in this condition, but in five cases treated with compression he reported that union was achieved "in an unusually short period of time". His claims were restrained, and in 1937 he described another technique, using a tibial graft as a central bone peg without compression force. In England the technique of positive compression is almost unknown, nor is it widely practised in the United States. In a recent personal communication Key still shows guarded enthusiasm, he goes no further than to state that the method is good. From experience of the use of compression I believe that this method is superior to any other, moreover, it has revealed side-issues which may have an important bearing on osseous union.

## TECHNIQUE OF POSITIVE PRESSURE ARTHRODESIS

Under a tourniquet the skin is incised in the midline, and the patella is excised. The knee is flexed and the bone ends are sawn in such a way as to give flat surfaces of cancellous bone which, when opposed, leave the limb almost but not quite straight. The bone surfaces are held together by an assistant and the edges of the skin wound are temporarily approximated by one or two volsella. This enables two parallel Steinmann nails to be passed, one through the upper end of the tibia and one through the lower end of the femur, without tension in the skin surrounding the nails when the wound is finally sutured (Fig 1). The nails are four millimetres in diameter and nine or ten inches long. The projecting ends are connected by special screw-clamps and the wing-nuts are tightened until the nails bow under the compression force (Fig 2).

Some points concerning the screw-clamp are worthy of note. The first Steinmann nail is passed carefully through the head of the tibia exactly at right angles to the long axis of the bone, taking care to avoid the external popliteal nerve. The passage of the second nail, parallel to the first, is secured automatically by using as a guide the screw-clamp attached to the first nail (Fig 1). The design of this clamp allows for the correction of rotation deformity. When the clamps have been tightened, rotation of the foot in relation to the axis of the femur can be corrected by slackening the wing-nuts. Since the metal blocks can rotate, the new position of rotation is held when the wing-nuts are tightened once more.

As a rule the knee is fairly rigid under this compression, and the fit of the cut surfaces is "hair-line" (Fig 3). Although quite rigid to forces causing lateral angulation, the mechanical system is potentially unstable to flexion and extension forces. For this reason external fixation is required after the final compression bandage has been applied. The best external splint is a Thomas' splint and here I differ from Key, who incorporates the pins in a plaster cast. I believe that plaster provides less protection than a Thomas' splint. Moreover the patient derives greater comfort if a Thomas' splint is used in this manner: a ring is chosen which is a neat fit for the groin, to get it past the projecting Steinmann nails the ring is cut just in front of the outer side bar with a hacksaw (Fig 4), the Steinmann nails rest on the side bars of the Thomas splint, provided that the knee is arthrodesed in no more than 5 degrees of flexion, with the nails resting on the splint all pressure is removed from the popliteal fossa and the patient is surprisingly comfortable, slings are applied under the leg and ankle and a foot piece is provided to support the foot. Radiographs of a typical case are shown in Fig 5.

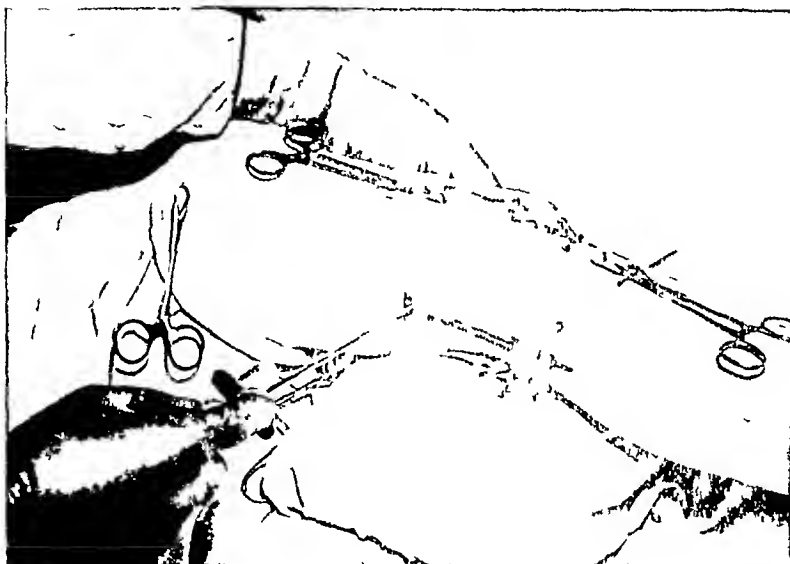


FIG 1

The joint has been excised and the surfaces are opposed. The first nail is at right-angles to the tibia. The second is being guided parallel to the first by the aid of the clamp. Note the stockinette and mastisol and the temporary closure of the wound while the nails are being inserted.

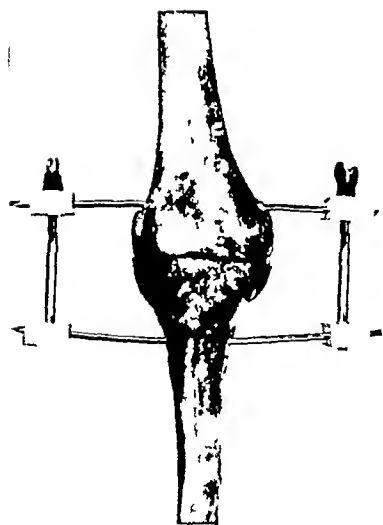


FIG 2



FIG 3

Fig 2 illustrates the arrangement of nails and clamps on the femur and tibia. Note the coaptation. Fig 3 shows the hair-line fit of the joint surfaces seen at operation.

A mechanical defect which has happened on three occasions has been spontaneous fracture of the four-millimetre Steinmann nails, due to slight erosion when the stainless steel is not of the highest quality. This annoying accident can be avoided by softening the nails by heating to red heat, cooling slowly, and repolishing—a procedure which can be done in any hospital engineering shop.



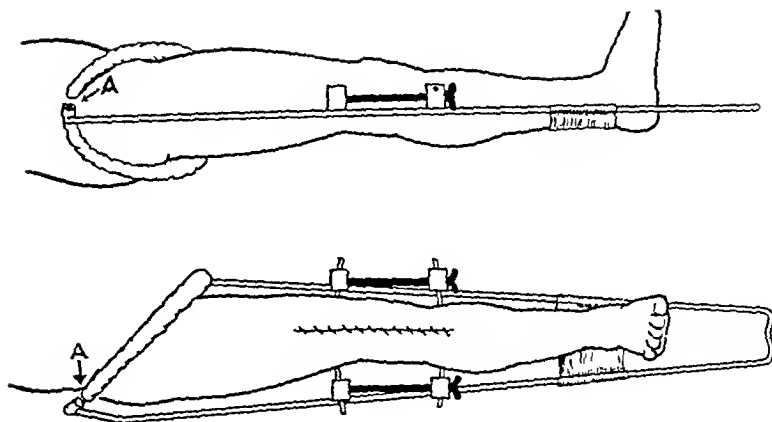


FIG 4

The ring is split at A to allow the Steinmann nails to pass. The nails rest on the side bars thus avoiding compression of the under-surface of the knee.

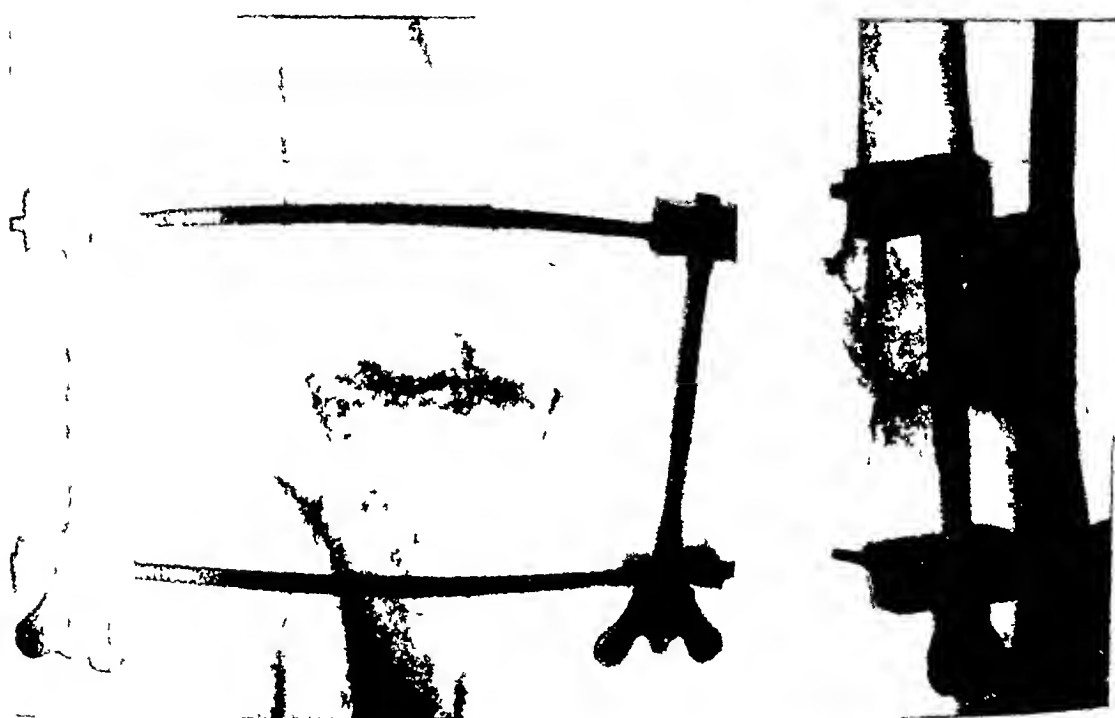


FIG 5

Radiographs after operation showing the close fit of the cut surfaces.

#### EXPERIENCE WITH THE METHOD

Fifteen consecutive arthrodeses have now been performed with completely satisfactory results, six were for old tuberculous disease of the knee joint with fibrous ankylosis in bad position, and nine for osteoarthritis. In the first three cases compression was maintained for six weeks before the joint was tested for union: all three showed firm clinical union. In one case the observation was made, though it did not arouse special interest at the time, that one of the Steinmann nails had fractured in two places despite the fact that there was solid union. Since it is unlikely that a nail would fracture *after* union had occurred, the bones were probably united some time before the end of six weeks. The fourth case was the one which revealed by accident that osseous union was taking place with unusual rapidity. On the ninth post-operative day, the patient had sudden pain in the knee and thought that "some thing had broken." Radiographs showed that one of the Steinmann nails had snapped. It



FIG 6

Case 4 The bone ends were united clinically when tested under anaesthesia on the twelfth post operative day



FIG 7

Case 4 Bone trabeculation crossing the line of arthrodesis after six months

was decided to substitute a new nail at the next convenient operating session three days later. On the *twelfth* post-operative day the patient was anaesthetised and the dressings were taken down, to the astonishment of everyone in the theatre the knee was clinically firm (Fig 6). Compression was therefore discarded and plaster was applied, bony union took place and in eight weeks the patient was walking without plaster and without discomfort.

After this surprising experience, I brought to the theatre two other patients who had been operated on fourteen days and twenty-one days before, in both, the arthrodesis was found to be clinically firm. The nails were extracted, plaster casts were applied, and weight-bearing was begun at once. The next case to be operated on (Case 7) was deliberately examined

fourteen days after operation, clinical union was again present, the nails were extracted and a plaster cast was applied. All these cases progressed uneventfully to sound bone union as shown in radiographs six months later (Fig 7). Although there could be no doubt from clinical tests that union by bone was present at twelve weeks, the radiographs naturally did not show evidence of it at so early a stage.

It seemed important next to establish the optimal duration for compression. Although it was apparent that clinical union could be present as early as twelve or fourteen days, this could in fact be nothing more than union by osteoid tissue, and no good purpose could be served by adopting so short a period of compression in every case. It was decided therefore that the routine should be four weeks' compression on a Thomas splint, four weeks' ambulation in a plaster cast, and four weeks' rehabilitation without splintage. With this sequence reliable union was present in eight weeks and the patient was fit for full employment twelve weeks after operation.

## DISCUSSION

**Comparison with other methods of arthrodesis**—The feature of this technique, which is in most clear contrast with other methods, is the accuracy of timing which is possible. It is known precisely when bone union will occur. With other methods the time of union seems to be quite indefinite, after various changes of plaster, slight movement at the excised joint slowly becomes less and less, thus giving the impression that union takes place after preliminary fibrous ankylosis. In fact one cannot help suspecting that the final state is sometimes no more than a firm fibrous ankylosis. Although this result may eventually be satisfactory, it means that full painless function is delayed for many weeks. In my experience arthrodesis of the knee joint by other methods takes an average time of six months and there is an appreciable incidence of failure. On the other hand, when compression is used in the manner described it may be predicted with certainty that the clamps can be removed after four weeks with the knee showing clinical union, that union by bone will be present by eight weeks as indicated by the absence of pain on straining the ankylosis, and that the patient will be fit for re-employment by the end of the third month. These claims may sound excessive, but unless they are stated in this manner the full significance of the method may not be appreciated and it might again be overlooked, as it was when first introduced some sixteen years ago.

**Rationale of the method**—In arthrodesis by compression, union takes place between two perfectly co-adapted surfaces of cancellous bone with intact circulation. Union of the arthrodesis is thus comparable to that of a fracture without displacement under ideal conditions. Both the cut bone surfaces share actively in osteogenesis. By contrast, methods of arthrodesis which depend upon a bone graft seem illogical. Though it is customary to state that a bone graft can be used to combine the functions of internal fixation and osteogenic stimulation, in actual fact a graft provides very imperfect fixation, and cortical bone has less power of osteogenesis than the bones which it joins together. When bone grafts are used, whether from the tibia, the tibial tubercle, or the patella, they probably act as no more than "passengers" for three or four months until they have secured a blood supply. It is unlikely therefore that grafts are capable of mechanical function in less than four or five months.

These adverse criticisms of the bone graft in intra-articular arthrodesis might be used in planning the ideal arthrodesis. The principle of using living bone to secure early union is of course applicable only where the bones forming the joint lend themselves to this purpose. When anatomical conditions make it impossible to hold the living bone-ends firmly together, a bone graft may be the only choice, but it should be regarded as a necessity rather than as a method of election. This axiom applies only to intra-articular arthrodesis, it conflicts in

no way with the use of bone grafts in extra-articular arthrodesis because here the method is chosen to avoid disturbing local pathology inside the joint

In its particular application to the knee joint, compression arthrodesis offers two points of detail which are worthy of remark. In the first place it is quite unnecessary to use a hip spica after operation, a Thomas' splint is enough to support the system in its weakest direction, namely the plane of flexion and extension. Secondly, it is free from the danger of fracture at the donor site of a tibial graft. This is a real hazard, because there is undue strain on the tibia when the natural shock absorber of a mobile knee joint has been removed.

**The influence of compression on bone union**—Few observations have been recorded on the effects of bone compression on fracture union, though the general impression exists that firm bone contact is beneficial. This impression may perhaps be derived more from the known ill-effects of distraction than from direct observation on the effects of compression. Against the value of compression is the common knowledge that heavy pressure may stimulate osteoclasia rather than osteogenesis. Moreover, many fractures, with complete lack of contact of the fragments, unite by profuse periosteal callus. In this method of compression-arthrodesis, three physical factors are simultaneously in action: (a) apposition of bone surfaces, (b) fixation of the fragments, (c) compression.

**Apposition of bone surfaces**—The less accurate the apposition of cut bone surfaces the more space there is in which fibrous tissue can develop as an interposing membrane. In compression-arthrodesis, exactness of coaptation can be very perfect indeed, this in itself could be regarded as an important factor in facilitating union, even in the absence of compression force. On the other hand the most instructive case in the series (Case 4) was that in which spontaneous fracture of a nail demonstrated accidentally that clinical union was present as early as the twelfth day, and this case had the least perfect coaptation of any (Fig 8). At the end of the operation on this patient the knee was found to be flexed nearly 20 degrees, and instead of removing a further bone wedge I decided to let the arthrodesis gape posteriorly. The knee was forced straight by another 10 degrees and fixed in the Thomas' splint by appropriate slings. This manoeuvre was possible because the nails hold the knee with only moderate rigidity against angulation in the sagittal plane. The effect was to increase pressure between the anterior parts of the bone ends and to put an increased strain on the apparatus, this may have contributed to the fracture of one of the nails. This experience suggests that perfect coaptation of the bone surfaces, though an obvious mechanical advantage, is not the main influence in producing very early clinical union.

**Fixation of the fragments**—The isolated effect of fixation on the healing of fractures is another fundamental matter on which there have been few direct observations. Many feel that absolute fixation inhibits the production of periosteal callus, as may often be seen after the treatment of fractures by Lane's plates, and conversely that slight movement, as in the treatment of fractures of the femoral shaft, increases the development of periosteal callus. In compression-arthrodesis, for technical reasons, the degree of fixation varies slightly from case to case. Fixation is of a high order if the pins are accurately centred and the clamp is



FIG 8

Case 4. Lateral radiographs showing the posterior gap after operation yet with clinical union on the twelfth day. The area of bone contact was under extreme pressure anteriorly. Note the nail holes.

well designed. At other times a distinct range of movement may be possible, particularly if improvised compression apparatus such as a cord, bandage, or rubber tube, is used instead of special clamps. Close scrutiny reveals perceptible flexion movement, even in the firmest of cases, if strain is applied.

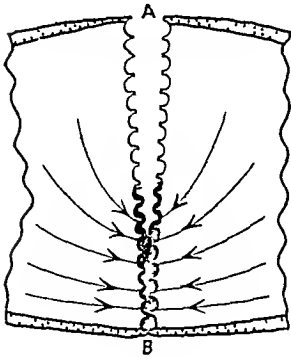


FIG 9

Continuous compression involves only a minute excursion between trabeculae near the hinge (B) whereas some distance away (A) there is considerable excursion. A flexible bridgehead can be established near the hinge.

There is also histological evidence that excessive movement predisposes to the formation of cartilage at a fractured line instead of woven bone.

Contrast this with what must happen in compression-arthrodesis. Angulating strains cause the line of excision to gape, but as soon as the strains are removed the fracture line closes. Such angular movement can be repeated continuously *but under the force of compression the trabeculae which are in contact at the hinge are relatively fixed* (Fig 9). At the fixed point of the hinge the osteoid fringes can blend, some distance away, the movement may be too great and this may be impossible. It is reasonable to expect that the pre-osseous substance or osteoid tissue has the flexibility of connective tissue such as cartilage. Thus bending movement may be possible without loss of continuity. Once a continuous bridge of osteoid is established in the absence of shearing movements it may ossify rapidly even though continuously subject to slight bending movements. The process of ossification can then extend laterally even if exact co-adaptation of the cut bone surfaces is not present.

Further consideration of Case 4 suggests another interesting possibility bearing on the nature of ossification. It is held by most histologists that the ultimate conversion of osteoid to bone takes place by the deposition of bone salts, and that it is largely a chemical reaction. Theories advanced from time to time suggest that this chemical phase is related to physical phenomena such as a changing pH value in tissue fluids at the fracture site. In Case 4 the nail fractured on the ninth day, causing sudden pain which necessitated a sedative. It may be presumed from the

In assessing the contribution made by fixation to early clinical union it is impossible to eliminate the two other factors, namely "fit" and compression, because a poor "fit" with heavy compression gives considerable rigidity, as does a good "fit" with moderate compression. My observations convince me that absolute fixation is rare and that it cannot be the main reason for such early clinical union.

**Hypothesis**—A theoretical point of interest now emerges. If one considers an arthrodesis fixed by any method other than compression, slight movement progressively loosens the fixation, be it internal or external, until a certain excursion is present. If we visualise this movement between opposing trabeculae, we see that it affects *all* trabeculae at *all* parts of the cut bone surfaces, and that the movement can be of any type varying from longitudinal separation to lateral shear. In general, unless a continuous force is present tending to push the cut surfaces towards each other, movement tends to separate them until fibrous tissue grows between. Under these conditions the opposing fringes of osteoid tissue, thrown out by the cut trabeculae, cannot blend.

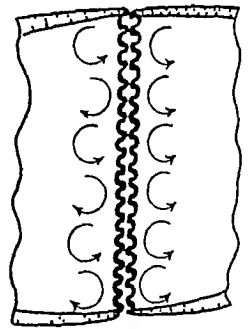


FIG 10

When there is no compression, any movement at the joint line is shared equally at all points along the cut surfaces. This invites shearing which prevents the establishment of an osteoid bridgehead.

sudden pain that the fracture was still capable of slight movement. Between the ninth and twelfth post-operative days, however, clinical union took place and fusion became firm. After fracture of the nail, the compression force did not disappear entirely because one-half remained in the bone and was still held by the clamps, but the compression force must have been diminished. I am tempted to suggest that an "osteoid bridgehead" had become established by the ninth day under the influence of compression, and that when the nail fractured, the "bridgehead" remained intact by virtue of its elasticity, and ossified during the next three days.

**The action of compression**—The most obvious effect of compression is the simple impaction of cancellous surfaces until trabeculae almost interdigitate. The force actually used has been measured by a simple device in which the clamps are screwed against a grip dynamometer until the nails show a curvature equivalent to that seen in the radiograph. No less than sixty to eighty pounds of pressure were registered by this method (Fig 11). Whether such pressure has special virtue in producing early union must remain a subject for speculation, we know only that it assists mechanical fixation and thus aids union. I feel, however, that there is probably some real virtue in high compression force and suggest two possible mechanisms.

In the first place, high compression forces act only on the "high spots" between opposed bone surfaces. At these points of very high pressure osteoclasia may be stimulated, with

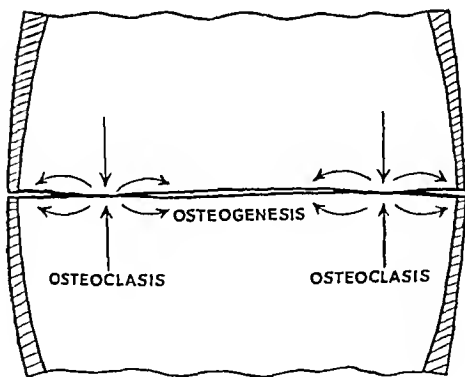


FIG 12

A theoretical conception of bone union under compression. The compression force generates high pressures at the high spots in contact where osteoclasia takes place. The bone substance may be redeposited at a site of low pressure.

consequent absorption of the "high spots," thus allowing the rest of the bone surfaces to come into intimate contact. *Pari passu* with the local removal of bone by osteoclasia the bone substance thus made available may be redeposited by osteoblasts a few millimetres away at points where there is no pressure (Fig 12). This suggestion of local transference of bone substance by cellular activity seems more acceptable than many of the chemical theories of ossification which, in the past, were accepted widely.

In the second place, compression-arthrodesis gives rise to dynamic forces which stimulate cellular activity. If the process of union after plating a fracture is visualised, one cannot imagine any stimulus for union if there is absolute fixation, and if the plate transmits all strains. By contrast, in compression-arthrodesis the compression force may evoke in sensitive

osteoblasts a response to the stimulus of function. Under the influence of compression the dynamic process of union contrasts markedly with the slow progress which is observed when bones lie passively splinted during early weeks.

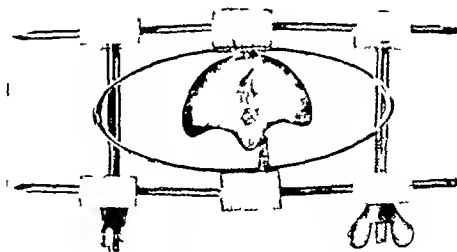


FIG 11

The degree of compression force is illustrated by a simple dynamometer held between two wooden blocks and transmitted by Steinmann nails. There is 80 pounds of pressure.

## SUMMARY

- 1 The technique of compression-arthrodesis of the knee joint is described
- 2 Fifteen consecutive cases are reported in which clinical union was detected at the first inspection from twelve days to six weeks after operation By this method the total period of disability is reduced to three months
- 3 Three mechanical factors which might be responsible for this very early clinical union are examined compression is believed to be the main factor, although fixation is also important
- 4 A fallacy is exposed in the use of bone grafts for arthrodesis of the knee, the graft is less osteogenic than the substance of the bones which form the joint, and it provides inefficient internal fixation
- 5 A theory is suggested that compression, even in the presence of slight movement, acts by producing a fixed "hinge" without shearing movement, at this point a bridgehead of flexible osteoid tissue is established in which ossification inevitably takes place despite slight bending movement
- 6 A second theory is suggested that high compression forces stimulate early union by liberating bone salts at points of maximum pressure through the action of osteoclasts, and that the local excess of bone salts is redeposited under cellular activity within a range of a few millimetres where there is no pressure

It is with pleasure that I acknowledge encouragement and advice from Sir Harry Platt in whose Department this work was carried out, and from Professor S L Baker of the Department of Bone Pathology in the University of Manchester I am also grateful for the time and patience which has been expended by Dr R G W Ollerenshaw and Mr Kulshaw of the Medical Department of Photography

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# THE CONSERVATIVE TREATMENT OF SCIATIC PAIN BY IMMOBILISATION IN A PLASTER JACKET

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*Short paper read at the British Orthopaedic Association Meeting in Exeter April 1947*

There has been much discussion as to the relative merits of operative and conservative treatment of sciatic pain due to prolapse of an intervertebral disc. The late results of operation have not always been as satisfactory as was expected, but on the other hand it is possible that conservative treatment may be palliative rather than curative.

All cases of sciatic pain treated at the Princess Elizabeth Orthopaedic Hospital, Exeter, between 1936 and 1945, were therefore examined. Most of these had been treated by the relative immobilisation of a plaster jacket, and this paper is a summary of the results. In order to be sure that we were in fact reviewing cases of sciatica likely to be due to retro-pulsion of an intervertebral disc, only those cases which showed abnormal neurological signs such as absent knee or ankle jerks, sensory disturbance, or motor weakness, were followed up.

Of 525 patients with sciatic pain, there were 225 (44 per cent) with definite neurological signs, including in the 147 traced absent ankle jerks, forty-seven (32 per cent), diminished ankle jerks, forty-four (30 per cent), absent knee jerks, three (2 per cent), sensory disturbance, fifty-four (36 per cent), muscle wasting, eighty-two (56 per cent). It was not possible to trace seventy-eight of these patients. Of the 147 who were traced, including eighty-two men and sixty-five women, the majority of the men were employed on heavy occupations (80 per cent) and most of the women were married and engaged in active household duties. The age groups were

Under 20 years	11	7.5 per cent
20-30 years	40	27.0 "
30-40 years	56	38.0 "
40-50 years	31	21.0 "
Over 50 years	9	6.5 "

There was no spinal deformity in sixty-three (43 per cent), homolateral scoliosis in thirty-five (24 per cent), contralateral scoliosis in forty-seven (32 per cent), and alternating scoliosis in two (1 per cent).

In most cases (123 out of 147) treatment consisted of immobilisation in a plaster jacket, extending from two inches below the nipple line to the symphysis pubis anteriorly and the lower part of the sacrum posteriorly, and kept in position for two to three months. The jacket was applied with head traction, not with the object of correcting scoliosis, but simply in order to steady the spine. In the majority of cases ambulation was possible as soon as the plaster was dry, and pain was much relieved within one or two days. If pain persisted, the patient was kept in bed and skin traction was applied to the leg.

The application of a plaster corset is better than simple recumbency in bed, because it affords more complete protection of the lumbar spine, thus allowing more complete relief of nerve root irritation, and encouraging reduction of the prolapsed intervertebral disc with consequent relief of spinal muscle spasm. Simple bed rest over a period of many weeks offers less control of spinal movement, delays rehabilitation of the patient, and involves wastage of hospital beds.

**Results of treatment by the protection of a plaster jacket**—Of the 123 patients treated in plaster jackets, forty-three were cured (34 per cent), thirty-five were relieved (29 per cent),



and forty-five were not relieved (37 per cent) \* By "cured" is meant complete relief of pain, with no recurrence over a period of two to ten years, the patient meanwhile continuing his ordinary occupation and leading a normal life By "relieved" is meant that there was very little residual pain, that during a period of two to ten years after treatment there were not more than three recurrent attacks necessitating rest in bed for two or three days, and that the patient continued heavy duties though often "sparing" himself and avoiding the lifting of heavy weights By "not relieved" is meant that pain was never completely controlled, or that there were many recurrences requiring bed-rest for more than a few days

It is to be noted that of the forty-three patients who were cured, twenty-nine (67 per cent) were treated during their first attack, ten (23 per cent) had suffered one previous attack, and only four (10 per cent) had had two or more previous attacks It is also instructive to examine the duration of symptoms in patients who were cured, relieved, and not relieved

Duration of symptoms	Cured	Relieved	Not relieved
One year or less	27 (42 per cent)	20 (31 per cent)	17 (27 per cent)
One to five years	7 (19 " )	11 (30 " )	19 (51 " )
More than five years†	9 (41 " )	4 (18 " )	9 (41 " )

Clearly the prospect of relief or cure by simple plaster immobilisation becomes less as the duration of symptoms increases

Finally it may be noted that the more complete the neurological signs the less is the prospect of relief by simple plaster immobilisation Of twenty-one patients who before treatment displayed all three signs—diminished or absent ankle jerk, hypo-aesthesia, and wasting of the calf, only 14 per cent were cured, 48 per cent were relieved, and 38 per cent were not relieved

**Neurological signs before and after treatment**—In 115 cases examined at long period after the conclusion of treatment a comparison was made of the neurological signs before and after treatment—

	Before treatment	At ' follow-up '
Absent ankle jerk	38	41
Diminished ankle jerk	39	16
Absent knee jerk	1	1
Hypo-aesthesia of leg	45	47
Wasting of calf	66	42

It is evident that when an ankle jerk is once lost it is unlikely to return, but that diminution of an ankle jerk often disappears when symptoms are relieved Furthermore, sensory disturbances due to nerve root pressure persist in the majority of cases

**Results of treatment by other methods**—Twenty-four of the 147 patients who were traced had not been treated in plaster jackets They included a few who had been manipulated and others who were treated by simple rest or physiotherapy Twenty-four cases cannot be compared with 123, but the proportion of cured, relieved, and not relieved cases was much the same in this group as in those treated in plaster, namely cured 7 (29.2 per cent), relieved 9 (37.5 per cent), not relieved 8 (33.3 per cent), but as a whole these were the less severe cases which showed promise of settling without specific treatment

\* Sixteen of these subsequently being treated by laminectomy

† Some of these cases had been free from symptoms for six or more years The significant figure is 41 per cent *not* relieved

## SUMMARY

1 Between 1936 and 1945, 525 patients with sciatic pain were treated at the Princess Elizabeth Orthopaedic Hospital, Exeter. Of these, 225 had neurological signs and they were selected for review, 147 were traced.

2 Of these, 123 were treated by means of plaster jackets and twenty-four were treated by other methods. The late results of treatment in the two groups were about the same, roughly one-third being "cured," one-third "relieved," and one-third "not relieved."

3 Nevertheless examination of the immediate results suggests that protection by means of a plaster jacket had at least a palliative effect, relieving acute symptoms and allowing early rehabilitation. Moreover it should be emphasised that in limiting the investigation to cases of sciatica with evidence of nerve root pressure only the more severe cases have been included.

4 Permanent relief after immobilisation in plaster was greatest when the duration of symptoms was short, and when the patient was treated during his first attack. It was least in patients who showed all three signs of nerve root pressure—diminished ankle jerks, hypo-aesthesia, and muscle hypotonicity.

5 Absence of tendon reflexes due to nerve root pressure, and areas of hypo-aesthesia, tend to remain permanently, but diminution of reflexes and loss of muscle power may recover.

I am indebted to Mr Norman Capener under whose care most of the patients were treated and whose practice of the conservative method has made possible this investigation.

# BONE LENGTHENING

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Disparity in the length of the lower limbs, if it amounts to more than two inches, may present a serious handicap. Apart from the mechanical inconvenience, the psychological effect is often very great and the individual suffers from inability to compete on equal terms in the labour market. The problem of equalising the length of the lower limbs is therefore of considerable importance, and it has attracted a good deal of attention especially in America. Whether equality in length is better gained by lengthening the shorter limb, or by shortening the longer limb, is a matter for discussion. Both methods have their advocates.

## HISTORICAL REVIEW

The first recorded attempts to lengthen a limb were described by Codivilla in 1905. His best results were secured by forced lengthening under narcosis by using a sudden and intense pull on a nail transfixing the os calcis after oblique osteotomy through the femur, the increase in length being held by a retentive plaster case, and the process being repeated at intervals. In twenty-six cases, including eleven malunited fractures of the femur, increase in length from three to eight centimetres was obtained. When excessive force had been used, epileptiform fits were noted two or three days afterwards. In 1912, Freiberg, using the Codivilla method, reduced shortening of two and one-quarter inches in a malunited fracture of the femur to half an inch. In 1913 Magnuson sought to show by experiments on dogs that two to three inches of lengthening of the human femur was possible without damage to the soft tissues because he was able to gain three-eighths to a half-inch in the animal without such damage. He described fourteen cases where lengthening was produced by traction on a Hawley table over a period of twenty to thirty minutes. All the patients were greatly shocked, and one died. In 1913 Ombredanne elongated a femur by three centimetres in a case of infantile paralysis with four centimetres of shortening. In 1921 Putti published a paper on "Operative lengthening of the femur." He applied traction and counter-traction directly to the shortened bone. His apparatus consisted of two metal pins driven into the proximal and distal fragments, projecting only on the outer side of the limb where they were connected by means of a spring-loaded telescopic tube. No other external fixation was used until elongation was complete, when the whole limb was fixed in a plaster spica. Difficulty in maintaining alignment, and some delay in union, were experienced.

**Abbott's operation**—In 1927 Abbott described a method of tibial elongation, which with modification became a standardised operation in America. In his first series of six cases he considered it unwise to lengthen the tibia more than two inches, but greater increases have since been obtained by many surgeons. After dividing the tibia, traction and counter-traction were maintained by means of Steinmann pins above and below the osteotomy. The steps of Abbott's operation were 1) lengthening the tendo Achillis, 2) osteotomy of the fibula, 3) insertion of the drill pins, 4) osteotomy of the tibia, 5) application of the distraction apparatus. He divided the periosteum of the tibia completely around the bone, and the deep fascia on the antero-lateral aspect of the leg. Subsequent writers emphasised the importance of dividing these structures together with the interosseus membrane and the fibular inter-muscular septum, though they may be done at a different level to the osteotomy. One of the chief difficulties was to avoid forward angulation of the fragments from the bowstring



FIG 1



FIG 2

An example of femoral lengthening. Tuberculous arthritis of the hip joint with unsound ankylosis and three inches of shortening (Fig 1). After the femoral lengthening operation there was a gain in length of three inches.



FIG 3



FIG 4

An example of tibial lengthening. Congenital shortening of the tibia with absent fibula, deficient toes and severe equinus deformity of the foot (Fig 3). After tibial lengthening with elongation of the tendo Achillis and stabilisation of the foot, good function was regained with over four inches gain in length (Fig 4).

action of the tautened leg muscles Carrell sought to avoid this by a third pin placed in front of the fragments, but serious skin sloughing was observed by others who used this technique. Many types of apparatus have since been tried, most aiming at greater rigidity and better control of the fragments.

**Complications of leg lengthening**—In 1936 Compere summarised the case for and against bone lengthening. He found that every surgeon who had attempted the operation had encountered complications, some of a very serious nature. These can be divided into three groups: 1) due to overstretching, 2) due to interference with the blood supply to the fragments, 3) due to insufficient fixation of the fragments. It is believed that the last two groups of complications could be overcome or avoided by alterations in the operative technique and the retentive apparatus.

**Indications for leg lengthening**—The indication for a lengthening operation is limb shortening exceeding one and a half inches. Less than this, unless the hip or spine is stiff, can be accommodated by pelvic tilting, or by a combination of pelvic tilting and shoe raising.

**Contra-indications of leg lengthening**—The contra-indications are: 1) poor control of both hip and knee joints requiring permanent splintage, 2) age of the patient—only adolescents and young adults are suitable subjects, 3) shortening so great that the fitting of an artificial limb with or without amputation would be better, 4) recent or active bone or joint infection, 5) very tall persons in whom shortening of the opposite limb should be considered, 6) faulty nutrition of the short limb.

**Principles of the distraction apparatus**—The success of the operation depends to a large extent on the distraction apparatus, and it determines almost entirely the comfort of the patient during the lengthening phase. The ideal is a piece of apparatus in which the only possible movement is in the long axis, and in which secondary deformity such as forward angulation of the bone fragments and equinus and valgus displacement of the foot do not occur. As has been pointed out by Barr and Ober (1933) these foot deformities are not prevented by preliminary stabilisation or tendon lengthening.

It is believed that the tibial distraction apparatus used in this series fulfils these requirements. It was modelled to a certain extent on that of Haboush and Finkelstein, but the Kirschner wires are held in stirrups clamped in a carrier, so that one pair is fixed and the other pair moves together away from the fixed pair. In a later model the distance between each one of the pair can also be altered. The use of detachable stirrups is important. When the apparatus is adjusted, the stirrups bend by reason of their elasticity, they accumulate the distractive force and transmit it gradually to the limb so that distraction proceeds smoothly and not in a series of jerks. Angulation and foot deformity are prevented by enclosing the whole limb after operation in plaster from the toes to the groin. The plaster is secured to the apparatus by the transfixion wires and by struts beneath the heel and the thigh.

### TECHNIQUE OF LEG LENGTHENING

Operative procedures, as previously described, can be much simplified. The very complete division of soft structures advocated by many writers is unnecessary, and complications due to impoverishment of blood supply to the ends of the fragments by excessive periosteal stripping, and marked post-operative swelling and inflammatory reaction from wide dissection, are avoided. The aim is to produce an oblique osteotomy of the bone, leaving the periosteum as far as possible intact, and inflicting the minimum of damage to soft tissues.

**Tibial lengthening**—In tibial lengthening a curved incision is made over the front of the leg about its middle, with the convexity outwards. The periosteum covering the tibia is exposed through the required length, and the line of an oblique osteotomy, three to four inches in length, is outlined by drill-holes piercing both cortices. The front of the bone is

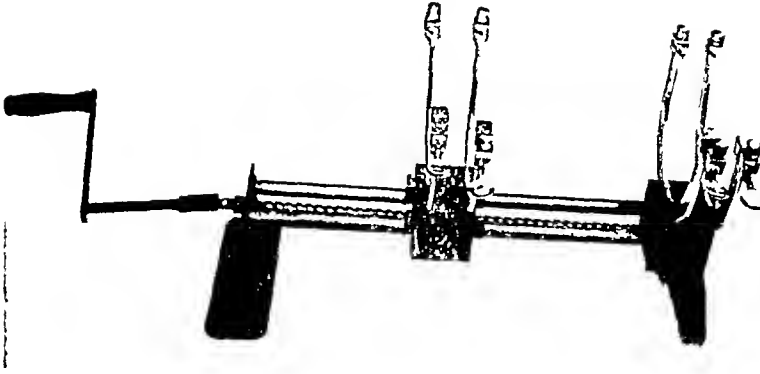


FIG 5  
Apparatus for tibial lengthening

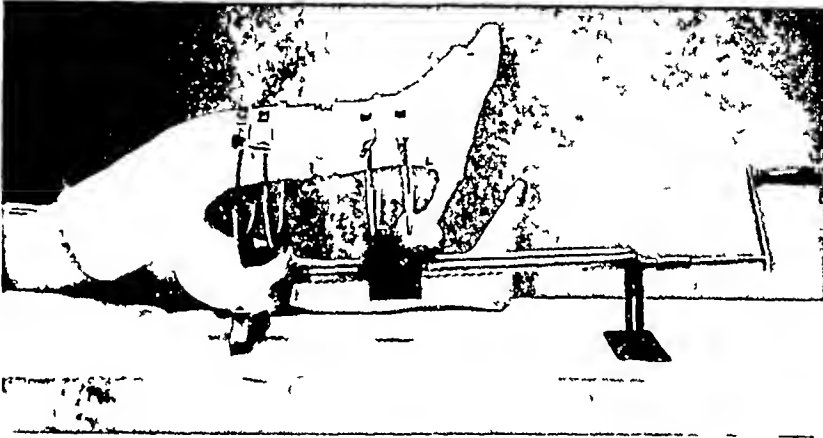


FIG 6  
Tibial lengthening apparatus incorporated in plaster which is strengthened under thigh and heel. Distraction has begun; note the gap in the plaster which is equivalent to the length already gained. The equinus position of the foot was present before operation.

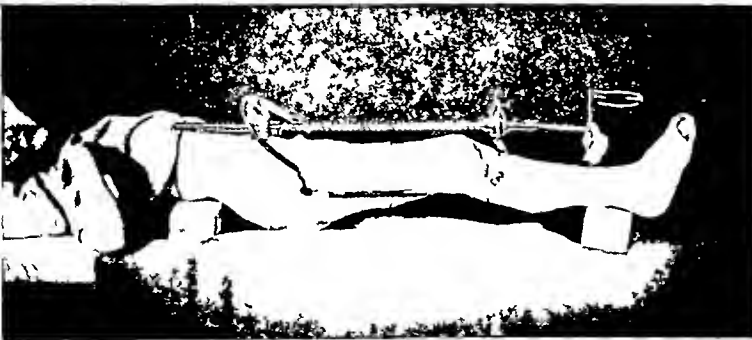


FIG 7  
Apparatus for femoral lengthening. Note the telescopic tube incorporated in the plaster. In later operations the stirrups were fitted as close as possible above and below the osteotomy.

then divided in the line of the drill-holes with an osteotome, and the back breaks in the same line. The periosteum at the sides is left intact, and it does not tear completely at the back. The fibula is reached through the same incision and is divided transversely with bone forceps. Four wires are inserted from side to side, two above and two below the osteotomy,



FIG 8

Lengthening of tibia. The gap between the tibial fragments is nearly consolidated the bone being laid down with longitudinal striation. In this case the fibula failed to elongate correspondingly and the lateral malleolus was displaced upwards about one inch. No deformity or disability resulted.

and fixed to the distraction apparatus. The limb is covered with dressings and it is heavily padded with felt or thick wool under the sole, over both malleoli, behind the tendo Achillis and over the head of the fibula. It is at these places that subsequent twisting strains are resisted, and sores are liable to appear. Plaster of Paris is applied firmly from toes to groin. When set, the plaster is divided transversely about the centre of the osteotomy. Distraction

is started immediately, and proceeds at the rate of one-sixteenth of an inch a day, it is continued until the required length is gained. This can be judged fairly accurately by the gap in the plaster, which opens as the limb lengthens. The only error is in the curving of the wires, and the extent of this can be seen in radiographs. Little pain should be experienced



FIG 9

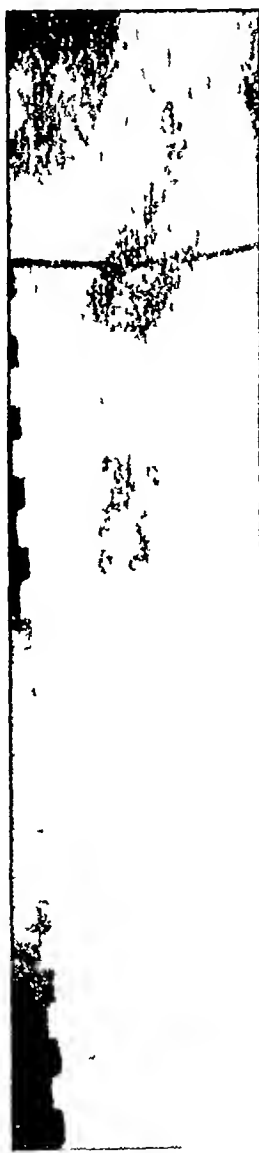


FIG 10



FIG 11

Congenital shortening of the femur—note the coxa vara and sclerosis of the upper femoral shaft (Fig 9). At operation the upper tongue of the Z-shaped osteotomy broke off but nevertheless distraction was continued (Fig 10). Eleven months later the gap was filled with dense bone. Ten years later the new bone is consolidated and recanalized—it is now less dense at the site of osteotomy than above and below (Fig 11).

Excessive aching indicates that the rate of lengthening is too rapid. Local pain or soreness suggests pressure on one of the vulnerable points, in these circumstances the distraction should be relaxed temporarily, and a small window made in the plaster to relieve pressure. When enough increase has been gained the apparatus is left in position until radiographs show sufficient callus between the fragments to prevent collapse. Then, while union is still



plastic, the plaster and wires are removed, alignment is adjusted, the normal curve of the bone is restored, and the limb is fixed in plaster until union is complete

**Femoral lengthening**—Femoral lengthening presents greater difficulty. Angulation of the fragments and secondary deformities are not so troublesome as in the tibia, but stiffness of the knee joint, temporary or even permanent, is a frequent complication. It is also difficult or impossible to place transfixion wires all in the same plane, owing to the varying relation of the great vessels and nerves to the bone. At the level of the lesser trochanter the direction of the wire must be almost directly from before backwards, while above the femoral condyles it must be from side to side. Putti's original method seems to be the most straightforward, but Abbott and Crego (1928) recorded great difficulty in using this technique because the pins were insecure and alignment of the fragments could not be controlled. It is possible that if the apparatus were incorporated in a plaster spica, with telescopic tubes to prevent angulation, these objections might be overcome.

TIBIA AND FIBULA		FEMUR	
Infantile paralysis	28 cases	Tuberculous arthritis of hip (Seven with bony ankylosis)	15 cases
Congenital shortening (Four with absent fibula)	7	Malunited fracture	6
Tuberculous arthritis of hip (One with bony ankylosis)	3	Tuberculous arthritis of knee (Three with bony ankylosis)	5
Osteomyelitis of tibia	3	Congenital shortening (One with dislocated hip)	5
Tuberculous arthritis of knee (Fibrous ankylosis)	1	Infantile paralysis (One with dislocated hip)	4
Other's disease	1	Osteomyelitis of femur (One with dislocated hip)	3
Hemiplegia	1	Septic arthritis of hip	1
Venous angioma	1	Unreduced congenital dislocation of hip	1
Rachitic shortening	1		
Malunited fracture	1		
Total	47 cases	Total	40 cases
Average lengthening obtained			
In the tibia—Two and one-third inches (including one failure)			
In the femur—One and five-eighths inches (including three failures)			
Average time before weight-bearing			
In the tibia—Six and one-half months			
In the femur—Five months			

In this series, several methods of femoral lengthening were employed

- 1) Traction by skeletal traction through the tibial tuberosity, with body-weight counter traction on an inclined plane, or on a Dunn sliding bed. There was no difficulty in keeping the fragments in line, but no certainty in gaining the required length.
- 2) Traction and distraction through the tibial tuberosity and the upper part of the femur. Control of alignment was easy, but there was risk of strain of the knee joint, giving rise to subsequent stiffness, while the upper wire, if placed too high, cut out of the bone. Distraction by a wire through the ilium was tried on two occasions and each time it cut out.
- 3) Traction and distraction through compact bone above and below and as near as possible to the osteotomy. Control of alignment was more difficult, but there was less risk of knee stiffness, especially if the osteotomy was placed high in the bone. This procedure has remained the method of choice.

The operation is performed in a similar manner to the tibial operation. The periosteum is disturbed as little as possible. Two Kirschner wires and stirrups are used, the higher is

directed from before backwards and the lower obliquely from within outwards and backwards, thus avoiding the main vessels and nerves. The stirrups are connected by the distraction apparatus, the whole is incorporated in a plaster spica from the waist to the toes, with telescopic tubes in front and behind to prevent angulation.

### RESULTS OF LEG LENGTHENING

Patients with limb shortening due to a variety of causes were submitted to operation. Cases were rejected only if the nutrition of the limb was deficient, or if there had been recent infection. Patients with infantile paralysis were treated by lumbar sympathectomy before being subjected to leg lengthening. In pyogenic bone and joint infections, at least six years was allowed to elapse, but in tuberculous infections of the hip joint elongation was attempted two years after quiescence, and in tuberculosis of the knee joint four years after quiescence. Most cases were done at the age of thirteen or fourteen years, before growth had ceased. This was because they were maintained in hospital, partly by the Board of Education, otherwise, operation might well have been deferred until the age of sixteen years or even longer. There were eleven adults in the series. They presented no special difficulties and did as well as the children.

The greatest lengths below the knee were gained in cases of congenital shortening: in four the figures were three and a quarter inches, four and a quarter inches, three and a half inches, and four inches. Six other cases were lengthened three or more inches. The only failure was a case of congenital shortening aged one year with already one and a half inches of shortening, where the traction wire cut out through the heel. Later the shortening became so severe that amputation was performed. Above the knee, three inches was gained in two cases of tuberculous arthritis of the hip joint, and two or more inches in fifteen other cases. The failures were two cases of congenital shortening and one tuberculous arthritis of the hip joint. In each of these, the upper wire cut gradually through the bone, giving a false impression of lengthening, and the fault was not discovered until union had begun. The gains in each were half an inch only.

In no case of tuberculous arthritis was the disease reactivated. In three cases of osteomyelitis, there was slight recrudescence of activity which did not interfere with the result. In one case of congenital shortening of the femur, where traction was applied through the upper part of the tibia, the femur and tibia separated at the knee joint by nearly one inch. After release, the ligaments tightened rapidly and full mobility was regained with no instability.

### REACTION OF TISSUES TO LENGTHENING

**Reactions of bone to lengthening**—Observations have been made on the reaction of tissues to the operation. In bone the response is similar to that which occurs after fracture, though it is somewhat delayed. Within two months the radiograph shows bone laid down in parallel lines between the fragments, suggesting that osteogenic material is strung out across the gap. Since it is known that the periosteum is intact, it is likely that much of it comes from that source. In some femoral lengthenings the rate of new bone formation has been so fast that distraction had to be stopped before the proposed length was secured. The bone density is the same as that seen after a fracture, except that where a complete gap occurred through the breaking of a tongue or from over-distraction, increased density resulted. All bones returned to normal radiographic appearances within a year or so of consolidation. In one case of congenital shortening of the femur where the bone before operation was of ivory-like density, the osteotomy was made through the dense part, and after healing a much more normal texture was observed, suggesting that nutrition of the bone had been improved.

Union occurred in every case, but there was marked delay in twelve cases, union taking from nine to sixteen months. The cause of the original shortening seemed to have no relationship

## TIBIAL LENGTHENING

Case No	Date of operation	Age	Diagnosis	In inches				Complications	Time before full weight bearing
				Shortening			Lengthening obtained		
				Femur	Tibia	Total			
1	25/5/33	13	Osteomyelitis of tibia	0	3	3	2½	Flake sequestration front of one fragment	6 months
2	26/11/33	12	Osteomyelitis of tibia	0	2½	2½	2	Flake sequestration front of one fragment	5 months
3	31/10/34	16	Infantile paralysis	0	1½	1½	1½	None	12 months
4	3/8/34	1	Congenital shortening	0	1½	1½	0	None	1 month
5	22/1/35	15	Infantile paralysis	0	1¾	1¾	1¾	None	7 months
6	10/5/35	10	Infantile paralysis	1	1½	2½	1½	None	3 months
7	5/7/35	10	Infantile paralysis	0	2	2	2¾	None	5 months
8	1/10/35	16	Infantile paralysis	1	3	4	2½	None	3 months
9	18/10/35	14	Hemiplegia	½	1½	2	2½	None	7 months
10	14/1/36	14	Infantile paralysis	0	1½	1½	1½	None	3 months
11	20/2/36	16	Congenital shortening	1	3½	4½	3½	Transient external popliteal paresis Small sequestrum	9 months
12	7/7/36	13	Infantile paralysis	½	1½	2	2½	None	4 months
13	13/10/36	14	Infantile paralysis	0	2½	2½	3	None	6 months
14	15/12/36	13	Infantile paralysis	1½	2	3½	2½	None	5 months
15	8/1/37	12	Osteomyelitis of tibia	0	1½	1½	1½	Small sequestrum Transient external popliteal paresis	6 months
16	4/6/37	12	Infantile paralysis	0	2½	2½	1½	Slight skin slough under tread	4 months
17	15/6/37	13	Infantile paralysis	½	2¾	3½	2½	None	8 months
18	27/8/37	19	Infantile paralysis	0	2	2	2½	Slough sole of foot Transient external popliteal paresis	7 months
19	31/8/37	12	Infantile paralysis	0	1¾	1¾	1¾	None	6 months
20	7/9/37	16	Infantile paralysis	1	2¾	3¾	2¾	Slough under tread	6 months
21	2/11/37	15	Rachitic bowing and shortening	0	1	1	1	None	4 months
22	22/3/37	20	Infantile paralysis	½	3	3½	3	None	5 months
23	1/2/38	15	Infantile paralysis	0	1½	1½	2	None	4 months
24	4/2/38	18	Infantile paralysis	½	1½	2	2	None	5 months

TIBIAL LENGTHENING—*continued*

Case No	Date of operation	Age	Diagnosis	In inches				Complications	Time before full weight-bearing
				Shortening			Lengthening obtained		
				Femur	Tibia	Total			
25	1/4/38	15	Congenital shortening of tibia Absent fibula	0	5	5	4½	Transient external popliteal paresis	10 months
26	25/2/36	12	Infantile paralysis	0	1½	1½	2	Transient external popliteal paresis	5 months
27	7/1/39	16	Congenital shortening of tibia Absent fibula	0	4½	4½	4	Probable transient external popliteal paresis	8 months
28	19/1/40	14	Infantile paralysis	½	1½	2½	2¾	None	7 months
29	21/3/40	15	Malunited fracture	0	1½	1½	1½	None	3 months
30	1/11/40	14	Infantile paralysis	0	1½	1½	1½	Transient external popliteal paresis	5 months
31	14/12/40	21	Infantile paralysis	0	2	2	2	Slough behind heel	5 months
32	29/11/40	13	Infantile paralysis	0	1¾	1¾	1¾	External malleolus displaced upwards 1 inch	4 months
33	29/4/40	15	Infantile paralysis	½	2½	2¾	2¾	None	7 months
34	19/9/41	11	Ollier's disease	2	5	7	3½	None	6 months
35	3/10/41	23	Congenital shortening	1½	2½	4	2	Gross residual stiffness in knee	8 months
36	30/10/42	17	Tuberculosis of hip	1½	1½	3	1½	Sore sole of foot and front of ankle	6 months
37	10/9/43	15	Infantile paralysis	1	3	4	3½	None	8 months
38	14/2/44	14	Infantile paralysis	½	2½	3	3½	None	11 months
39	19/6/44	15	Infantile paralysis	½	2½	3	3	Temporary ankle stiffness	9 months
40	7/5/45	14	Infantile paralysis	½	2	2½	2½	Gross decalcification Pathological fracture above ankle	9 months
41	12/5/45	11	Congenital short tibia Absent fibula	0	2½	2½	2¾	Skin necrosis front of tibia	6 months
42	11/6/45	26	Infantile paralysis	0	2½	2½	2½	? Transient internal popliteal nerve paresis	6 months
43	21/9/45	15	Tuberculosis of hip	4	2	6	2	Transient external popliteal nerve paresis	6 months
44	13/10/45	13	Congenital short tibia Absent fibula	1¾	2½	4	3½	Delay in union	16 months
45	15/11/46	20	Tuberculosis of hip	1	3	4	3	None	8 months
46	9/12/46	15	Venous angioma	0	1½	1½	1½	None	7 months
47	11/1/47	20	Tuberculosis of knee	2½	2	4½	1½	None	9 months

## FEMORAL LENGTHENING

Case No	Date of operation	Age	Diagnosis	In inches				Method	Complications	Time before full weight bearing
				Shortening			Lengthening obtained			
				Femur	Tibia	Total				
1	22/9/31	13	T B knee	4	$\frac{1}{2}$	$4\frac{1}{2}$	$1\frac{1}{2}$	Traction on inclined plane	None	$3\frac{1}{2}$ months
2	10/2/32	13	T B knee	3	0	3	1	Traction on inclined plane	None	5 months
3	19/2/32	16	T B hip	3	3	6	$2\frac{1}{2}$	Traction on inclined plane	None	8 months
4	28/3/33	16	T B hip	$2\frac{1}{2}$	0	$2\frac{1}{2}$	$1\frac{1}{2}$	Traction on inclined plane	Tongue of one fragment broke off	$3\frac{1}{2}$ months
5	16/12/32	13	Congenital shortening	$4\frac{1}{2}$	0	$4\frac{1}{2}$	2	Traction on inclined plane	Tongue broke off	7 months
6	7,2/34	16	T B hip	$2\frac{1}{2}$	0	$2\frac{1}{2}$	$1\frac{1}{2}$	Traction on inclined plane	None	$3\frac{1}{2}$ months
7	29 5,34	13	Malunited fracture	$1\frac{1}{2}$	0	$1\frac{1}{2}$	1	Traction on inclined plane	External popliteal nerve paresis Recovered in 6 months	6 months
8	15 6 34	12	Malunited fracture	2	0	2	$2\frac{1}{2}$	Traction on inclined plane	Refracture at a lower level 2 months after discharge	4 months
9	28/8/34	15	T B hip	3	1	4	$2\frac{1}{2}$	Traction on inclined plane	Fleeting external popliteal nerve paresis	3 months
10	5/7/34	16	Congenital shortening	3	1	4	$\frac{1}{2}$	Traction through tibia Distraction through ilium	Upper wire cut out Marked stiffness in knee	6 months
11	27/7/34	13	T B hip	$2\frac{1}{2}$	0	$2\frac{1}{2}$	1	Traction on inclined plane	Some residual knee stiffness	4 months
12	—	14	Infantile paralysis	$1\frac{1}{2}$	$\frac{1}{2}$	2	$1\frac{1}{4}$	Traction on inclined plane	None	4 months
13	14/5/35	13	T B hip	$2\frac{1}{2}$	1	$3\frac{1}{2}$	3	Traction through tibia Distraction through upper end of femur	External popliteal nerve paresis Recovered in 7 months Residual stiffness in knee	6 months
14	23/6/36	14	T B knee	$1\frac{1}{2}$	$\frac{1}{2}$	$2\frac{1}{2}$	2	Traction through tibia Distraction through upper end of femur	None	5 months
15	2/8/36	12	Congenital shortening Dislocated hip	2	$1\frac{1}{2}$	$3\frac{1}{2}$	$\frac{1}{2}$	Traction through tibia Distraction through upper end of femur	Upper wire greater trochanter cut out	5 months
16	19/10/36	15	T B hip	3	1	4	2	Traction through tibia Distraction through upper end of femur	Residual stiffness in knee	9 months

FEMORAL LENGTHENING—*continued*

Case No	Date of operation	Age	Diagnosis	In inches				Method	Complications	Time before full weight-bearing
				Shortening			Lengthening obtained			
				Femur	Tibia	Total				
17	26/7/37	17	Osteomyelitis of femur Infantile paralysis	2	2	4	2	Traction through tibia Distraction through middle of femur	Sepsis in wound	6 months
18	7/9/37	11	Infantile paralysis Dislocated hip	3½	0	3½	1½	Traction through tibia Distraction through upper end of femur	Decalcification of the femur and the tibia	11 months
19	16/10/37	10	Congenital shortening	6	0	6	2	Traction through tibia Distraction through upper end of femur	Distraction at knee joint Rapid return to normal with full movement	6 months
20	7/10/38	14	T B hip	1½	0	1½	½	Traction through tibia on inclined plane	None	3 months
21	14/10/38	17	T B hip	3	1	4	2	Traction through lower end of femur Distraction upper end of femur	Temporary loss of flexion in toes	5 months
22	27/1/39	13	T B hip	2	1	3	2	Traction through lower end of femur Distraction through upper end of femur	Some residual stiffness in knee	6 months
23	16/6/39	21	T B hip	2	1	3	3	Traction through lower end of femur Distraction through upper end of femur	Paresis external popliteal nerve Recovered in 5 months	3 months
24	12/10/40	22	Malunited fracture of femur	2	0	2	1½	Traction through centre of femur on inclined plane	Some residual stiffness in knee	5 months
25	17/1/41	12	Malunited fracture of femur	1½	0	1½	1½	Traction through tibia on inclined plane	Paresis external popliteal nerve Recovered in 4 months	4 months
26	19/12/41	22	T B hip	2	1	3	2	Traction through lower end of femur Distraction through upper end of femur	Marked residual knee stiffness	12 months
27	16/1/42	10	T B hip	2½	1	3½	0	Traction through tibia on inclined plane	None	4 months
28	2/10/42	16	T B hip	3	1	4	1	Traction centre of femur Distraction upper end	None	7 months

FEMORAL LENGTHENING—*continued*

Case No	Date of operation	Age	Diagnosis	In inches				Method	Complications	Time before full weight bearing
				Shortening			Lengthening obtained			
				Femur	Tibia	Total				
29	—	35	T B knee	2	1	3	1½	Traction through tibia on inclined plane	None	4 months
30	17/9/43	14	Congenital shortening	2¼	0	2¼	2	Traction centre of femur Distraction upper end of femur	External popliteal nerve paresis Recovered in 4 months	5 months
31	7/9/42	16	Malunited fracture	2	0	2	1½	Traction centre of femur Distraction upper end of femur	Slight sepsis upper wire	4 months
32	14/12/45	20	Dislocated hip	1¾	0	1¾	2	Traction centre of femur Distraction upper end of femur	Some residual knee stiffness	4 months
33	30/5/46	19	Osteomyelitis of femur	3	1½	4½	1½	Traction through centre of femur on inclined plane	None	4 months
34	14/12/46	16	Septic arthritis hip	3	2	5	1	Traction through centre of femur on inclined plane	None	5 months
35	13/11/45	14	Osteomyelitis of femur Dislocation of hip	3½	0	3½	1	Traction lower end Distraction upper end of femur	Upper tongue broke 40 degrees movement in knee after 18 months	6 months
36	20/1/47	15	Infantile paralysis	3½	2½	6	2	Traction lower end Distraction upper end of femur	None	7 months
37	11/1/47	20	T B knee	2½	2	4½	2	Traction through tibia Distraction through upper femur	None	9 months
38	21/1/47	10	Malunited femur	1½	0	1½	1½	Traction through centre of femur on inclined plane	None	4 months
39	9/6/47	15	T B hip	3	3	6	2	Traction through centre of femur on inclined plane	None	3 months
40	25/6/47	6	Malunited fracture of femur	1½	0	1½	1	Traction through tibia Well leg counter-traction	None	1 month
			Average				1½			

to this delay, except that three were in cases of congenital shortening of the tibia with absent fibula. In these three cases there were gains of three and a quarter inches, three and a half inches, and four and a quarter inches respectively. The gains in the other cases of delayed union were, however, relatively small.

In two cases, both leg bones became grossly decalcified. No explanation was forthcoming and union was only slightly delayed. One suffered a fracture just above the ankle whilst the apparatus was being removed. This united in good position, and normal mobility returned to the ankle joint without further delay.

A boy of sixteen years, who had his femur elongated two and a half inches for a malunited fracture, was involved in an accident and broke it again at a lower level two months after discharge. It was reported that the accident was of such severity that the femur would probably have fractured even if it had been normal.

There were three cases of bone sepsis. Each was an example of osteomyelitis of the tibia, quiescent for many years. Sepsis was slight and healing took place after the separation of a small flake sequestrum from the front of the tibia, with no delay in union.

**Reaction of muscle to lengthening**—Muscles react badly to stretching. They offer little resistance, but it is difficult to maintain their nutrition, especially in the lower leg. As soon as they are in moderate tension the patient finds it difficult to maintain toe movements. By the time the apparatus is removed there is a marked degree of muscle wasting. Since, however, most below-knee cases have had infantile paralysis, and usually have a stabilised foot, or one which will have to be stabilised, this wasting is not of primary importance. Above the knee it is easier to keep the muscles working, and a window may be cut in the plaster in order to give faradic stimulation to the quadriceps.

**Reaction of periosteum, membranes, and fascia**—Probably the most resistant structures to stretching are the periosteum, the interosseous membrane, and the deep fascia. It is for this reason that many writers advocate free division of these structures. It is doubtful, however, if the advantages so gained outweigh the many disadvantages. If a positive method of elongation is employed, great resistance can be overcome. It is likely that the pain which is experienced arises from stretching of these structures, and that the rate of elongation must be adjusted accordingly.

**Reaction of blood-vessels to lengthening**—The blood-vessels appear to be able to withstand much stretching, provided that it is done slowly. In not one case in this series was there any hint of vascular embarrassment, apart from local skin anaemia due to uneven pressure.

**Reaction of nerves to stretching**—The nerves are less immune than the arteries. It would be thought that a series such as this should offer a satisfactory field for the study of nerve stretching. Unfortunately, the results have been inconclusive. In a large proportion of cases, nervous damage already existed, so that observation of the effects on motor power could not be assessed. In cases in which normal function was present, observation of toe movements was carried out. Here, however, difficulty was encountered. In lower leg cases, as length increased, the toes became drawn into plantar flexion, and it was difficult to distinguish between inability to dorsiflex through nerve failure, and inability to dorsiflex through increased tension of the flexor tendons. Three cases had temporary hypoaesthesia in the toes, otherwise there was no sign of interference with the internal popliteal nerve. Definite signs of external popliteal palsy were seen in fourteen cases—six in femoral and eight in tibial lengthenings. Of the cases of femoral lengthening, two were malunited fractures where the limb was being restored to normal length, one after only one inch, and the other after one and a half inches increase had been gained. In the other four, there had been an increase of over two inches in length before paralysis appeared. The longest time taken



for full recovery was seven months. In tibial cases the loss in conductivity was transient, all cases recovering before the apparatus was removed. The increase in length before the nerve was affected varied from one and a half inches to four and a quarter inches. The vulnerability of the external popliteal nerve to stretching may be explained by its fixation where it winds around the neck of the fibula. It must be remembered, however, that in below-knee cases the degree of stretching of the nerve is much less than half the lengthening of the bone, because the muscles receive their nerve supply in the upper half of the leg. In above-knee cases, the nerve is stretched to an extent equal to the elongation of bone. It is capable of stretching from the point of its emergence from the pelvis to the neck of the fibula, if not over a greater length, but mostly below the bifurcation of the sciatic nerve. Two nerves lost conductivity after less than two inches of stretching, two at two inches, and two at three inches. In many cases, up to two and a half inches was gained without nerve involvement. No nerve survived over two and a half inches of lengthening. It can therefore be stated fairly that the external popliteal nerve and the component part of the great sciatic nerve may be stretched two inches in the thigh over a period of four to six weeks without losing conductivity, and that it may be stretched three inches with only temporary impairment.

**Reaction of the joints**—In femoral lengthening it was the rule for the knee joint to stiffen temporarily, especially if one of the traction wires was placed anywhere near the joint, whether above or below. The stiffness usually passed off after a few weeks of exercise, but it persisted in ten cases, six regaining 90 degrees of movement in a year, and four in less than a year (one of these having had only 90 degrees before operation). In the worst result, 40 degrees of movement was regained within six years. The knee is usually unaffected in cases of tibial lengthening. One case, in which there had been previous femoral lengthening, stiffened temporarily. One other was a little stiff for a few weeks. In one case there was temporary ankle stiffness. The hip was never affected.

**Subluxation of the fibula**—In tibial lengthening the fibula often lagged behind the tibia, and this was not prevented by dividing the bone in two places instead of one. Usually the head was displaced downwards. This had no obvious effect on the external popliteal nerve, in fact, it probably eased tension in the nerve. Once the lower end of the fibula was displaced upwards for about one inch (Fig. 8) the foot did not deform, and no other change was seen in the ankle joint.

**Skin soreness and sloughing**—Skin soreness occurred in a few cases. This, however, is believed to be due to errors of technique which could have been avoided, because if proper attention is paid to the patient's complaints the affected area can be relieved of pressure before permanent damage is done. There was trouble from sloughing along the leg wound in tibial elongations when a gain of three inches or more was attained. This was thought to be due to local anaemia from excessive skin stretching. The only permanent effect was a wide scar. Sepsis along a traction wire occurred twice. This was in the days before chemotherapy was available. One cleared rapidly and permanently. The other persisted as a slightly discharging sinus in the upper part of the thigh, but did not prevent the patient from being called up for military service.

**Difficulties in leg lengthening**—The difficulties which have been encountered include  
1) In femoral lengthening the upper wire, if placed too high, gradually cuts out of the bone. All wires should be inserted through compact bone.

2) In four cases, one of the bone tongues broke off. This has occurred on no more than one occasion since an oblique osteotomy has been used instead of a Z osteotomy. Other writers have reported this accident, and have thereupon given up the attempt at elongation. However, since the periosteum was nearly intact it was thought safe to proceed and all such

cases did well. In one tibia a gap of three inches was opened, it filled with bone and became firm enough for full weight-bearing in five months.

3) There may be doubt as to whether the fragments have separated completely. To ensure that they have separated the fragments should be gently mobilised, but too much movement is unwise, because soft tissue damage is to be avoided. A small strip of undivided bone may prevent distraction.

### CONCLUSIONS

- 1 Two inches of lengthening may be gained in the femur, and three inches in the tibia and fibula, without complication.
- 2 More than this may be secured at the risk of temporary external popliteal paresis.
- 3 Lengthening of the tibia and fibula is more certain and more easy to control than lengthening of the femur.
- 4 Traction, and counter-traction through the bone, with complete lateral rigidity, are essential to success.
- 5 In applying this technique to the femur there is a danger of knee stiffness. The farther from the knee the skeletal traction pins are inserted, the less is the risk. The operation should therefore be planned as high as possible in the shaft of the femur.
- 6 The most delicate structure, and the one least tolerant of stretching, is the external popliteal nerve.
- 7 An oblique osteotomy, started by closely spaced drill-holes, is the best.
- 8 Certain vascular complications experienced by other surgeons are attributable to subperiosteal bone exposure, and to dividing the periosteum and fascial structures transversely.

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# ARTHRODESIS OF THE ANKLE JOINT

## Experiences with the Transfibular Approach

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The transfibular approach for arthrodesis of the ankle joint has in recent years been adopted as the standard procedure at a number of orthopaedic centres. At the London Hospital it has been employed in every case requiring ankle fusion during the last four years. The time may thus be opportune to record the technique of the operation and to form an estimate of its value.\*

### TECHNIQUE OF TRANSFIBULAR ARTHRODESIS

An incision, five inches in length, is made over the lower third of the subcutaneous surface of the fibula (Fig 1). It is prolonged downwards to a point half an inch distal to the tip of the lateral malleolus. The fibula is exposed subperiosteally and divided three to four inches from its lower end (Fig 2). The distal fragment is removed and prepared for use as an onlay graft by splitting off the inner cortex throughout its length. After stripping ligamentous tissues from the lateral aspect of the lower end of the tibia the ankle joint is clearly exposed in the lower half of the wound. The articular cartilage of both tibia and talus is then erased down to vascular bone, working from the lateral side with a gouge or osteotome. Trimming of the bones is carried out in such a manner that when the intervening gap is closed the foot rests in the optimal plantigrade position with a few degrees of equinus. Small spaces remaining between the bone ends are filled with cancellous bone chips. A bed is prepared for the fibular graft by freshening the lateral aspect of the tibia and astragalus (Fig 3). The cancellous aspect of the graft is applied to the graft-bed, bridging the joint space. The graft is secured by three screws, two of which grip the tibia and one the astragalus (Fig 4). The wound is closed and a plaster is applied. Weight-bearing in plaster is encouraged within a few weeks of operation. After twelve weeks, the plaster is removed for clinical and radiographic tests of fusion.

### ANALYSIS OF THE RESULTS

Thirty cases have been studied. In twenty-eight there was successful primary fusion in an average period of thirteen weeks. Illustrative series of radiographs in typical cases are shown in Figs 5 to 8.

[\* The technique of arthrodesis of the ankle joint by the transfibular approach with grafting of the fibula to the tibia and talus (or in the case of tibio-calcaneal fusion with grafting of the fibula to the tibia, talus and calcaneus) was developed six or eight years ago in the orthopaedic service of the Royal Air Force. That service was characterised by a magnificent team spirit in which exchange of ideas was so constant that to this day none of us knows with certainty who first conceived the brilliant idea of this simple and effective operation. Neither does any one of us believe that it is important to attach the name of a single surgeon to a particular operation. But if credit must be attached it should be shared by James C. Scott of Oxford, James Armstrong of London and John Crawford Adams of London, all of whom served as orthopaedic specialists in the Royal Air Force Orthopaedic Service.—EDITOR.]

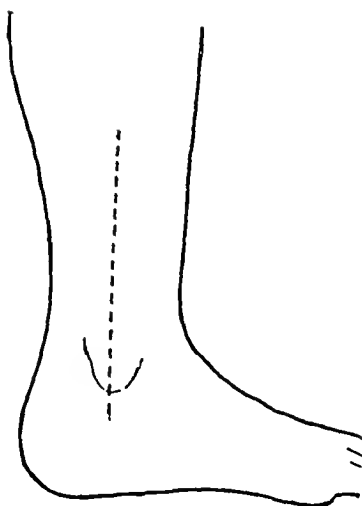


FIG 1



FIG 2

Technique of transfibular arthrodesis of the ankle joint. A five inch incision is made over the lower third of the fibula (Fig 1). The fibula is exposed. It is divided in its lower shaft and removed (Fig 2).

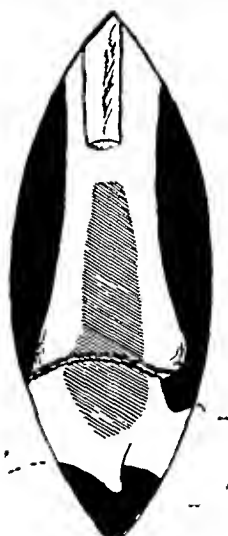


FIG 3

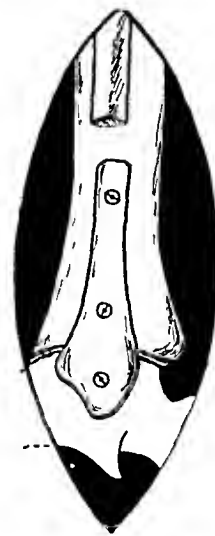


FIG 4

Articular cartilage is removed from the joint. The bone spaces are packed with cancellous chips and the lateral surfaces of the tibia and talus are freshened (Fig 3). The fibular fragment after being split to expose its cancellous surface is screwed in close contact with the tibia and talus (Fig 4).



FIG 5

Radiograph of old unreduced backward dislocation of the ankle joint

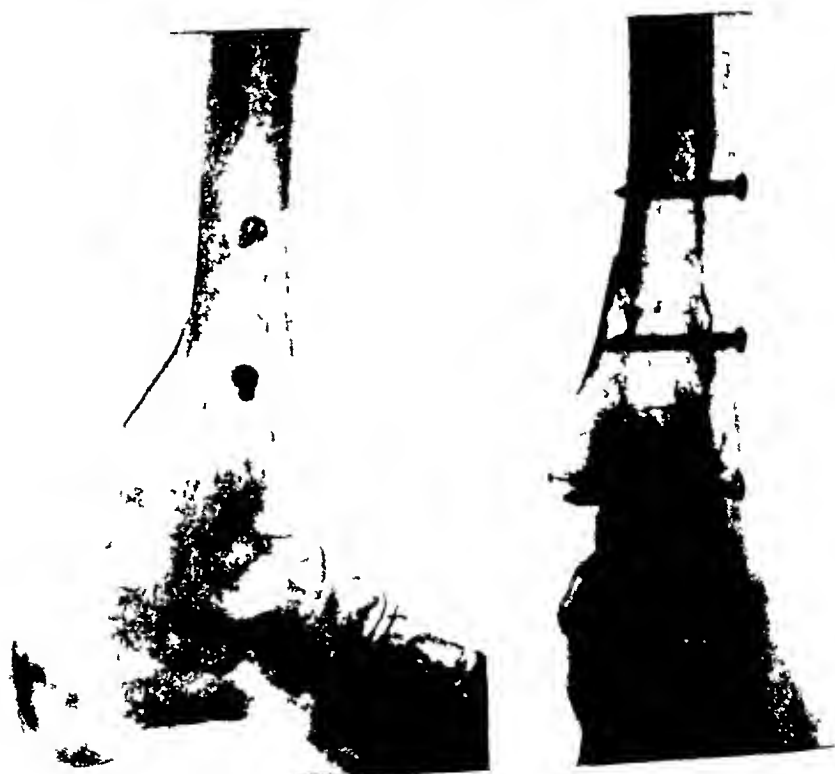


FIG 6

The joint has been arthrodeseised by the transfibular approach using the lower third of the fibula as an onlay graft



FIG 7

Another example of incongruity of the ankle joint surfaces due to old fracture dislocation



FIG 8

Arthrodesis has been performed by the trans-fibular approach the fibular graft being secured in this case by two instead of three screws



FIG 9



FIG 10

Disorganisation of an ankle joint after a gunshot wound. Arthrodesis of the subastragaloid joint had already been performed (Fig 9). Attempted fusion of the ankle joint by means of fibular grafting failed (Fig 10).



FIG 11



FIG 12

At a second operation rigid immobilisation was secured by means of a three flanged nail driven across the joint from below (Fig 11). The nail was removed after fourteen weeks by which time there was sound fusion (Fig 12).

In two cases there was failure of fusion and secondary operations were required. These two failures are instructive in that they illustrate important practical considerations.

**Case report**—A man aged 36 years was admitted for treatment of a painful and disorganised ankle joint resulting from an old gunshot wound (Fig 9). Arthrodesis of the subastragaloid joint had previously been performed and there was impairment of mid-tarsal movement. Four months after arthrodesis of the ankle joint there was no radiographic evidence of bone fusion (Fig 10). At a secondary operation the bone surfaces were freshened, cancellous bone chips were packed around the joint, and a long three-flanged nail was driven up from the lower surface of the os calcis into the tibial shaft (Fig 11). After immobilisation in plaster for fourteen weeks there was sound bone fusion.

This case illustrates the importance of providing rigid immobilisation after arthrodesis of the ankle joint in patients whose subastragaloid or mid-tarsal joints have previously been fused. The probable cause of failure of primary fusion of the ankle was that rigidity of the subastragaloid joint, and associated stiffness of the mid-tarsal joint, permitted the transmission of slight forefoot movements to the ankle during walking, with consequent shearing strain at the site of arthrodesis. In three subsequent cases in this series, in which subastragaloid fusion had previously been carried out, particular care was taken to prevent shearing movements by applying a closely moulded plaster extending well forward under the forefoot, and by deferring weight-bearing until twelve weeks from the time of operation. These cases showed satisfactory bone fusion on removal of the plaster at the fourteenth week.

The other failure in this series was due to an error of technique.

**Case report**—A female patient weighing sixteen stones (224 pounds) was admitted for treatment of painful osteoarthritis of the ankle resulting from an old fracture with malunion. Arthrodesis was performed but post-operative radiographs showed that the apposition of bone surfaces was poor. The transplanted fibula had not been applied in close apposition to the tibia and talus and an appreciable gap was obvious in the radiographs. Six months after operation there was no evidence of bone fusion. A secondary operation was performed: the bone ends were freshened and cancellous bone chips were packed firmly between and around the joint surfaces. Satisfactory fusion was then obtained after five months of plaster immobilisation.

There is little doubt that in this case the failure to secure primary fusion was due to inadequate apposition of the bone surfaces. This failure emphasises the importance of careful technique in shaping the bones in such a manner that there is close contact over a wide area. It suggests also the advisability of packing cancellous bone chips firmly around the joint and into any small spaces that may be left between the bones.

### DISCUSSION

With careful technique the transfibular approach for arthrodesis of the ankle joint can be relied upon. It is a method which has the merit of simplicity. Clear exposure of the articular surfaces is readily obtained. The onlaid fibular graft gives sound stability and affords a scaffolding for the formation of a stout bone bridge across the joint. Close contact between the tibia and astragalus is essential, and the packing of cancellous bone chips around the bones is an advantage.

When arthrodesis of the subastragaloid-mid-tarsal joint has previously been performed, or is performed at the same time, particular care is necessary to ensure that shearing strains are not transmitted from the forefoot. This demands rigid immobilisation. The plaster should extend well forward beneath the forefoot, and weight-bearing should be deferred until ten or twelve weeks after operation. An alternative procedure which gives adequate fixation is the use of a long three-flanged nail driven upwards from the lower surface of the calcaneus into the shaft of the tibia.

### SUMMARY

The technique of the transfibular approach for arthrodesis of the ankle joint is described. The results of this operation in a series of thirty cases shows that the procedure is reliable if the technique is carried out faithfully. The two cases in which a first operation failed can both be explained by errors of technique or after-treatment.



# NAILING THE FEMORAL NECK BY A SIMPLE METHOD

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Since nailing was introduced in the treatment of fractures of the femoral neck, many instruments have been devised for directing the nail, but experience has shown that they cannot replace judgment and skill. Many surgeons have therefore reverted to simple methods.

The work of Geckeler, Austin Moore, Tilson, Ransohoff, Gaenslin, and Glissan has shown that the fracture may be fixed efficiently, and rotation and angulation prevented, by two or more carpenter's nails or screws made of vitallium or rustless steel. Such methods inflict the least possible injury on the femoral head, a matter which is of decisive importance when regard is paid to the frail circulation in this fragment. Trauma to the soft parts, exposure of tissue, and risk of infection can also be reduced.

Some other complications of nailing are eliminated, such as catching of the guide wire in the cannula of the nail, and tilting of the femoral head when it is first struck by the massive flanged nail.

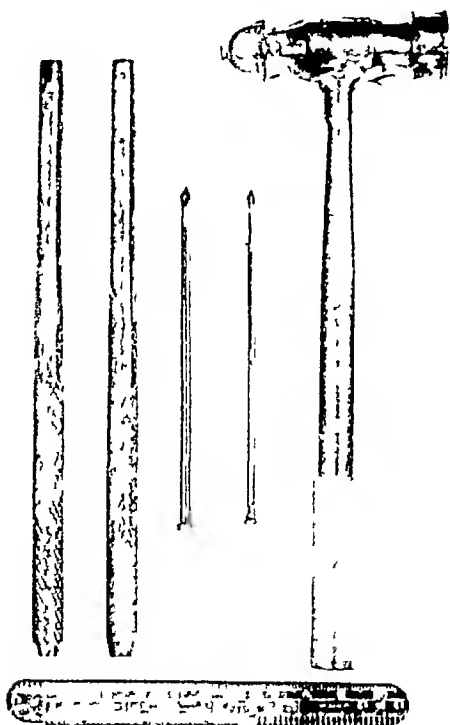


FIG 1

Instruments used in author's simple method of nailing the femoral neck

## AUTHOR'S METHOD

The few instruments required are shown in Fig 1. The two punches have their ends slightly hollowed. Two nails are used in most cases, some times three. The simple method to be described may however be used for the introduction of three flanged nails, preferably of the sharper and less massive original type.

The patient is given morphia gr  $\frac{1}{4}$ . An hour later a local anaesthetic (novocaine  $\frac{1}{2}$  per cent with adrenalin) is placed around or even into the fracture site through three points. Through one point, half-way between the tip of the great trochanter and the iliac crest, the anaesthetic solution is placed above and lateral to the fracture. Through a second point, about two inches below the inguinal ligament, and lateral to the femoral artery, the solution is placed below and in front of the fracture. If the joint is distended with blood the solution may be injected into the synovial cavity. Through a third point, on the lateral aspect

of the thigh near the lower margin of the greater trochanter, the solution is placed behind the neck of the femur and in the soft tissues over the lower part of the trochanter and the upper shaft.

The fracture is reduced on an orthopaedic table by the Leadbetter and Whitman manoeuvres. The feet are bandaged to the foot pieces with the limb in abduction and full internal rotation. Reduction is confirmed by radiographs in two planes.

Introduction of the nails is the next step. The points for insertion are selected on the radiograph. An assistant determines the length of nail by measuring in the antero-posterior view the distance between the circumference of the head medially and the cortex of the shaft laterally where the nails are to lie. To allow for magnification with a twenty-five inch target-film distance and a patient of average size, two or three centimetres are subtracted from these measurements. The amount subtracted is greater (3.6 cm) in big patients. The



FIG 2

Four years after nailing In later cases the nails were driven parallel



FIG 3

One month after nailing

nails thus selected, when driven home, are found to be a little longer than the depth of bone to be traversed. Their heads project slightly into the soft parts, but not beyond the fascia lata or sufficiently to cause irritation. The lower nail is longer than the upper nail. It is convenient to select nails of different diameter in order to distinguish them in the lateral radiograph.

refer to preliminary pain caused by carrying the point of the needle laterally, and this could be explained readily by direct nerve contact Johnston (1908) showed that in the thoracic region these branches "pass downwards, inwards and backwards superficial to the multifidus spinae muscle, until they reach the spinous processes of the upper thoracic vertebrae Before becoming superficial they descend by the sides of the spinous processes a distance which gets gradually greater as we pass from the first to the lowest member of the series, the nerves increasing in length" (Fig 2) In the thoracic region, therefore, injection near the mid-line would be almost certain to affect these nerves Lower down, however, in the lumbar region, they "run close to the articular processes of the vertebrae and end in the multifidus" (Gray's Anatomy 1946) If, then, the results are due to stimulation of the medial branches of the posterior primary divisions of spinal nerves, injection of hypertonic saline near the mid-line

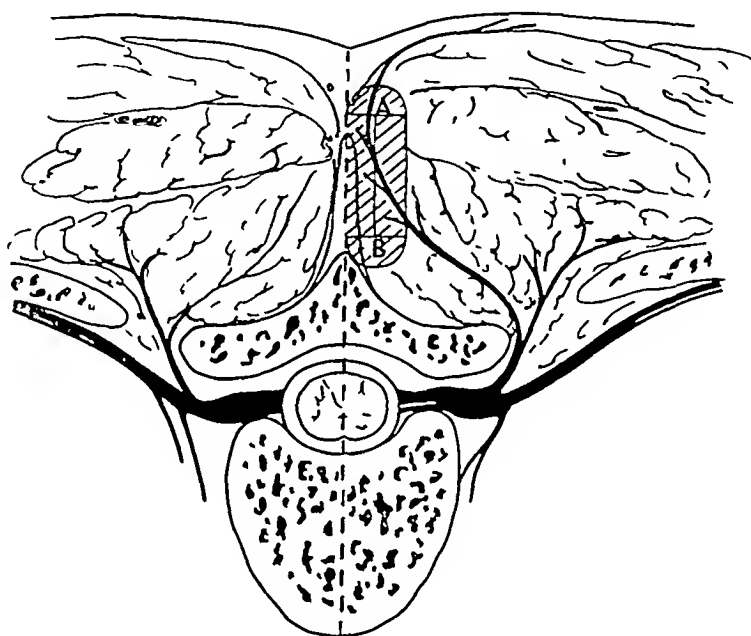


FIG 1

Diagram of transverse section through a thoracic vertebra (adapted from Spalteholz) If the technique of Lewis and Kellgren is followed the portion of the medial branch of the posterior primary division of the spinal nerve lying within the cross hatched area is liable to be directly affected by the injected saline

should elicit pain more readily in the thoracic region than in the lumbar region On the other hand, if the results are due to stimulation of interspinous ligaments, the reverse should hold good, owing to the larger size of these structures in the lumbar region

But, since neither Kellgren (1939) nor Lewis and Kellgren (1939) made accurate measurements of the position of the point of the needle, there remains another possibility It may be that the "tough interspinous ligament", or the "deep ligament" which they encountered to one side of the mid-line, was in fact the ligamentum flavum -If this is so, there is a distinct chance that in some cases the injected saline affected the posterior nerve root itself, since Falconer, Glasgow, and Cole (1947) demonstrated that extrathecal nerve roots in the lumbar region can be injected by means of a needle inserted about half an inch from the mid-line and directed straight forwards through the ligamentum flavum

These facts cast doubt on the validity of Lewis and Kellgren's assumption that their results were due simply to stimulation of the interspinous ligaments

## EXPERIMENTAL STUDY

In a preliminary study of the problem, 6 per cent saline was injected in various sites and at various depths in the lumbar and thoracic regions of the backs of a number of volunteers. The injections were made on the X-ray table, the needle being inserted through a small intradermal button of 1 per cent novocaine. The maximum quantity of saline injected in any one situation was usually 0.3 cubic centimetre, in conformity with the procedure of Lewis and Kellgren, but in some instances 0.6 cubic centimetre was injected. Before injection, the point of the needle was moved slightly in the tissues both vertically and horizontally, and the sensations were noted. The excursion of the point was not actually measured, but it must have been small because in all cases the point lay at a depth of 1 centimetre or more, and it was not withdrawn. In other experiments no injection was made, but the point of the needle was used as a probe, being partly withdrawn and reinserted at intervals in order to search a considerable area thoroughly. The position of the point at any desired moment was determined by taking one lateral radiograph, and two antero-posterior radiographs, with a tube shift of 10 centimetres, in order to give adequate parallax. In some instances fluoroscopic screening was used.

**Observations**—The importance of radiographic control was soon established, because without its aid it was found very difficult to predict with accuracy the position of the needle point. Indeed in every case it was found necessary to confirm the position of the needle point before injection, instead of simply using radiography as a check. The technique was time-consuming, but the position of the needle was never in doubt. In most cases, passage of the needle through deep tissues was not accompanied by discomfort other than a sense of vague "pushing," but in a few instances dull, unpleasant, aching pain was felt locally near the mid-line. On each such occasion radiographs showed that the point of the needle was in contact with the vertebra above or below, and this pain may be attributed therefore to stimulation of the periosteum by the needle point.

It was found that intervertebral injection of 0.3 cubic centimetre of 6 per cent saline made in the lower thoracic region, with the needle point at depths varying up to 3 centimetres and as near the mid-line as possible, always caused pain which was felt locally and was also referred to the distribution of the spinal segment. It was usually felt on one side of the body

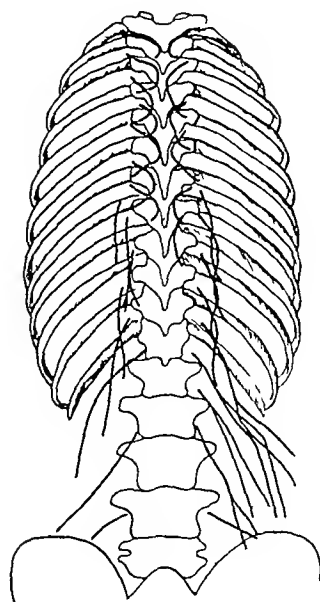


FIG 2

Diagram showing the *deep* course (in one subject) of those branches of the posterior primary divisions of the spinal nerves which eventually became cutaneous. Contrast their position relative to the mid line in the thoracic and in the lumbar regions. Note that muscular branches are not indicated in the drawing (after Johnston)

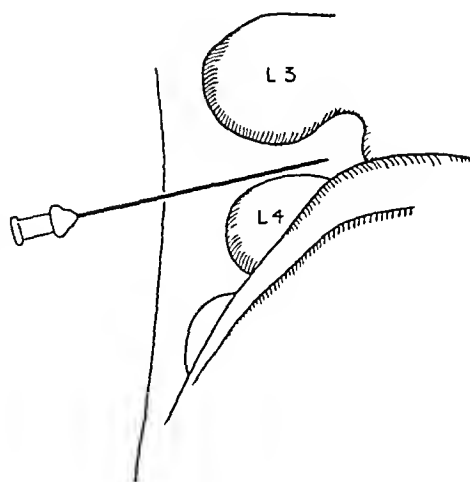


FIG 3

Tracing from control radiograph of mid line injection in the lumbar region indicating the position of the needle point in the interspinous ligament

only, though occasionally local pain transgressed the mid-line and was felt on both sides. If the needle was accurately placed in the mid-line the intensity and duration of the resultant pain were small, but if the point deviated even a few millimetres to one side, the pain, though similar in distribution, was much more intense, it lasted longer and it was accompanied by referred deep tenderness and cutaneous hyperalgesia. In fact it corresponded closely to the description given by Kellgren (1939). With the point of the needle half a centimetre from the mid-line, an injection of 0.1 cubic centimetre at a depth of 2 centimetres was sufficient to produce well-marked referred pain lasting for five minutes, deep tenderness lasting fifteen minutes, and cutaneous hyperalgesia persisting for ninety minutes. It should perhaps be noted that an injection of sodium penicillin (20,000 units per cubic centimetre in distilled water) made into the same site, later reproduced the whole clinical picture except that it was of brief duration.

In the lumbar region, where the interspinous ligaments are thicker and more readily injected, it was found that injection of 0.3 cubic centimetre of saline exactly in the mid-line gave rise only to mild local discomfort, and sometimes to no subjective sensation at all. An injection of 0.6 cubic centimetre was required before much pain was produced, even then, though of characteristically unpleasant quality, it was confined to a local area and was not referred segmentally. In one case a series of stimulations was carried out between the third and fourth lumbar vertebrae, each stimulation by the point of the needle being progressively more lateral. Not until the needle point was 3 centimetres from the mid-line, at a depth of 2 centimetres from the skin, was there referred pain, and an injection carried out at this point gave results similar to those described for the thoracic region.

It should be mentioned that, whereas in thoracic injections there was little or no sense of resistance, lumbar mid-line injections were accompanied by much resistance, suggesting that the fluid was being injected into dense tissue. Furthermore, local pain produced by injections in the mid-line in this region tended to persist, in one subject after an injection of 0.6 cubic centimetre there was considerable disability for a period of twenty-four hours. During this time there was never radiation of pain, it remained confined to the original site, around and just distal to the needle, and it retained its unpleasant quality. The persistence of the pain may be attributed to disruption of the ligament by the injected fluid, and it is interesting to note that an injection of novocaine into the site was temporarily successful in abolishing the pain.

**Summary of experimental observations**—To summarise it may be stated that in the thoracic region, injections made as nearly as possible in the mid-line caused referred pain much less readily than injections to one side of the mid-line. In the lumbar region injection of as much as 0.6 cubic centimetre of hypertonic saline into the interspinous ligament in the mid-line failed to cause referred pain, it caused only local pain in the back. Only when the needle point was carried laterally to a distance of about 3 centimetres was referred pain caused in one case by injecting 0.3 cubic centimetre of saline at a depth of 2 centimetres. It may therefore be said that in this series of experiments the results were consistent with the hypothesis that referred pain is caused by direct stimulation of nerve trunks, and inconsistent with the view that it is due to the stimulation of interspinous ligaments.

## DISCUSSION

Our results do not support the contention of Lewis and Kellgren that stimulation of an interspinous ligament by injection of hypertonic saline is capable of causing referred pain in the distribution of the spinal segment innervating the ligament. The results of injecting hypertonic saline close to the mid-line in the thoracic and lumbar regions cannot be explained on this basis. Furthermore, repeated failure to produce segmental pain by the injection of relatively large quantities of saline exactly in the mid-line of the lumbar region constitutes evidence against the theory. On the other hand, the findings are explained easily if it is assumed that they are due to direct stimulation of a nerve trunk in the vicinity.

Lewis and Kellgren observe that "there is no possibility of direct stimulation of spinal nerves," but they give no support for this statement other than that the stimulus is "local," and that "the response is invariable and immediate." It has been pointed out that the first of these reasons is misleading, owing to the relatively wide spread of saline after injection into a muscle, and the second could be used with equal force to sustain the opposite contention. Kellgren (1938) tries to distinguish the subjective results of stimulating nerve trunks and muscle by observing that when hypertonic saline is injected into a muscle and gives rise to a sensation of burning pain and pins and needles in the cutaneous distribution of a nerve trunk, this sensation is 'strikingly different from that produced by saline injected into muscle' he attributes such pain to the stimulation of a nerve. Nevertheless, both sensations are, in fact, the consequence of injecting saline into a muscle, and both are presumably conducted to consciousness by stimulation of sensory nerves in the muscle. In effect, therefore, both types of pain have a similar etiology, the difference being one of degree, and the more unusual type of pain is perhaps attributable to the injection of hypertonic saline directly into the substance of a mixed nerve trunk rather than into the immediate vicinity of the nerve. In this investigation there appeared to be only one type of pain, but it varied greatly in intensity according to the exact position of the needle. This finding may be interpreted as being due to the varying distances from the nerve trunk at which injections were made. In short, there appears to be no valid evidence against the assumption that pain produced by injecting hypertonic saline near the mid-line of the back is due to direct stimulation of one or more of the local nerve trunks.

Kellgren (1942) states that "the supraspinous ligament is intensely sensitive, the structures surrounding the neural arch are somewhat less so, and the vertebral bodies and discs are relatively insensitive." The first two parts of this contention appear to be based on the results of injecting hypertonic saline, for this reason they are open to question. No evidence is offered in support of the third part. Experience of lumbar puncture does not suggest that the supraspinous ligament is "intensely sensitive" to types of stimulation other than chemical irritation. In this series of experiments, piercing or scratching the supraspinous ligament with the point of a needle caused negligible pain.

Kellgren (1942) also maintains that stimulation of the supraspinous ligament causes local pain, while the deep-lying structures surrounding the vertebrae give rise to segmental pain, and the intermediate muscle mass gives pain of "modified segmental distribution." Elsewhere (1939) he remarks that the degree to which pain is localised depends on the depth from the body surface of the tissue under investigation: superficial structures give rise to local pain, deeper structures (in the chest wall) "give rise to diffuse pain of segmental distribution whether the structure stimulated be muscle, ligament or periosteum." In this statement there appears to be confusion between the ability to localise painful stimuli and the occurrence of referred pain. If these two factors are separated, the findings admit of a more simple explanation. It is now assumed generally that accuracy of stimulus-localisation in the skin is a function of the density of innervation (Weddell 1945). There is no reason to suppose that it is otherwise in deeper tissues, and since the density of innervation of these structures is far below that of the skin, it is not surprising that localisation of painful stimuli should be less accurate (Feindel, Weddell, and Sinclair 1948). The relative accuracy with which pain is localised after injection of hypertonic saline into the supraspinous ligaments is probably explained by leakage of fluid into the more densely innervated subcutaneous tissue. On the other hand these ligaments are superficial, and even without radiographic control it is easy to make certain that most of the saline remains in the vicinity of the ligament itself, and that it does not penetrate far enough to stimulate the medial branch of the posterior primary division. The absence of reference of pain from the supraspinous ligaments may thus be explained. In the case of muscles, it has already been submitted that pain produced by the injection of saline is the result of stimulation of the nerve trunks. Johnston (1908)

showed that the medial branches of the posterior primary divisions often communicate freely with their immediate neighbours in a tortuous course through deep tissues (Fig 4). It is therefore unlikely that stimulation of this network would always produce pain in a clear-cut segmental pattern. This is probably the reason for the "modified segmental distribution" described by Kellgren. Finally, it is likely that injections made round accessible parts of the vertebrae will be poorly localised if they do not stimulate a nerve trunk. They are, however, capable of impinging upon the posterior nerve root itself, with the production of full segmental pain.

Elliott (1944) using Kellgren's technique, found much variation in the site of reference of pain from the injection of hypertonic saline into the fourth and fifth lumbar "interspinous ligaments" in different subjects. It is interesting also to note that Gray (1947) denied that pain produced by this technique was referred on a segmental basis.

Kellgren (1942) argued that disease of the vertebral bodies seldom produced pain unless the neural arches were also involved, and (1941) suggested that localised kyphosis due to disruption of the nucleus pulposus might cause a variety of clinical syndromes. "The stretched supraspinous ligament may become painful, producing local pain in the mid-line of the back together with slight limitation of flexion and extension of the spine then the

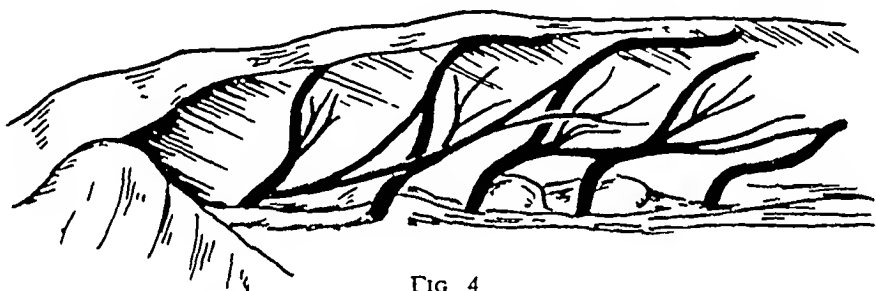


FIG 4

Lateral view of a dissection showing free communication between the medial branches of the posterior primary divisions arising from different spinal nerves in the thoracic region (after Johnston)

interspinous ligament and ligamentum flavum may become painful, giving rise to deep pain of segmental distribution together with great limitation of extension of the spine." There is nothing by which to prove that this hypothesis is untrue, but on anatomical grounds it is not well founded. Local lesions in the mid-line of the back may certainly cause profound disturbance—a fact of which both qualified and unqualified manipulative surgeons have long been aware. Steindler and Luck noted that they were able to suppress referred pain from such lesions by the injection of a local anaesthetic into the painful points. Kellgren (1941) confirmed this finding in sciatic pain, but he noted that it was unusual for the signs and symptoms to be suppressed completely by this procedure, explaining his failure by the difficulty in securing complete anaesthesia of the deep-lying structures. It is submitted, however, that the reason for incomplete suppression resides not in this difficulty, but in the failure to block local nerve trunks. In short, the evidence at present indicates that these lesions produce referred pain (which may simulate visceral disease) by direct involvement of some part of the segmental sensory nervous pathway.

#### SUMMARY AND CONCLUSIONS

1 The work of Kellgren (1939) and Lewis and Kellgren (1939) on the production of segmental pain by stimulation of structures near the mid-line of the back has been reviewed, and a number of experiments have been carried out with the object of testing the validity of their conclusions.

2 On both anatomical and experimental grounds there is reason to believe that pain produced in this manner does not arise, as was assumed by Lewis and Kellgren, from irritation of the interspinous ligaments, but is rather due to the stimulation of nerve trunks in the vicinity. The views of Kellgren (1941, 1942) on the etiology of pain in certain cases of sciatica, and on the part played by intervertebral ligaments in the production of pain in the back, have been discussed. They have been shown to rest on an inadequate foundation.

3 The importance in investigations of this kind of a detailed anatomical survey has been emphasized.

Our thanks are due for the invaluable assistance and interest of Dr A. D. Kemp and Miss Carmill of the Radiological Department of the Radcliffe Infirmary, Oxford. We would also record our appreciation of the great help rendered by the volunteers who participated in this investigation. The expenses of these investigations were defrayed by a grant to one of us (G. W.) by the Medical Research Council of Great Britain which is gratefully acknowledged.

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# BENIGN GIANT-CELL SYNOVIOMA AND ITS RELATION TO "XANTHOMA"

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In recent years increasing interest has been taken in tumours of synovial origin whether articular, bursal, or tenosynovial, and the literature has been enriched by many notable contributions. This communication is concerned primarily with the most frequent of these neoplasms, the so-called myeloid tumour of tendon sheaths or, as I prefer to call it, the benign giant-cell synovioma, and especially with its supposed relationship to "xanthoma."

Most of these tumours arise from tendon sheaths, especially those for the flexors of the fingers and thumb. There were forty cases in the routine surgical pathological material of the General Infirmary at Leeds during the years 1914-47. Of these, thirty are available for analysis.

*Age distribution*—These tumours seldom occur under the age of ten years, or over the age of sixty years.

TABLE I  
AGE DISTRIBUTION AT THE TIME OF OPERATION IN THIRTY CASES OF  
BENIGN GIANT-CELL SYNOVIOMA

Age periods	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79
Number	0	3	6	8	4	8	0	1

It may be remarked that whereas in this series of benign synoviomata twenty-six out of thirty (87 per cent) were encountered between the ages of twenty and fifty-nine years, in an almost contemporary series of 120 cases of osteoclastoma from the same hospital only seventy-two (60 per cent) occurred in this age group. This difference is due mainly to the greater frequency of osteoclastoma in the first two decades of life, but in part to the greater delay in seeking surgical aid for a slow-growing and unobtrusive lesion like benign synovioma.

*Sex distribution*—The ratio of males to females was seventeen to thirteen in the benign synovioma series and forty-three to seventy-seven in the osteoclastoma series.

*Site of occurrence*—The site of origin was stated, though not always exactly, in twenty-six of the forty cases, nineteen, or nearly three out of four, were situated in the fingers.

TABLE II  
SITE OF TWENTY-SIX CASES OF BENIGN GIANT-CELL SYNOVIOMA

Site	Fingers	Thumb	Hand	Wrist	Forearm	Toe	Foot	Knee
Number	13	6	1	1	1	1	2	1

The tumour of the knee was the only one in this series which was related definitely to a joint, but I have seen two others in this situation. It is obvious from these and other published figures that the site of election for this tumour is the digital tendon sheaths, especially of the hands. Malignant synoviomata on the other hand arise mainly from joints and bursae of the lower limbs. In Stout and Haagensen's collected series of 104 cases, nearly half (forty-nine) originated from the knee joint, almost a fifth (nineteen) in the region of the foot and ankle, and only four in the fingers.

## MORBID ANATOMY

The benign giant-cell synovium is a tumour of slow growth and firm consistency. It has usually been present for many months, or even a year or two, before being removed surgically. Excised specimens from the fingers are small and seldom more than two or three centimetres in diameter. Almost invariably they are situated on the flexor aspect. They usually show a deep, straight, narrow groove on one side. In this lay the tendon while the tumour was still in situ. Lobulation is often a prominent feature and the tumour is well defined. I have seen one case, however, in which the growth was adherent to, and indeed infiltrating, the overlying skin.

On section the cut surface is grey, but it usually shows yellow or brown flecking towards the periphery. The yellow flecking is due to deposits of cholesterol fat with its associated carotene. The brown pigment is haemosiderin, which gives a strong Prussian blue reaction with hydrochloric acid and ferrocyanide of potassium. Sometimes the whole tumour shows this yellow and brown mottling but more often it is distributed in a patchy manner (Fig 1). The heaviest grade of siderosis I have ever seen in a benign synovium was in one from the flexor tendon sheath of the great toe. It had attained an unusually large size and had no doubt been exposed to severe and repeated injury.

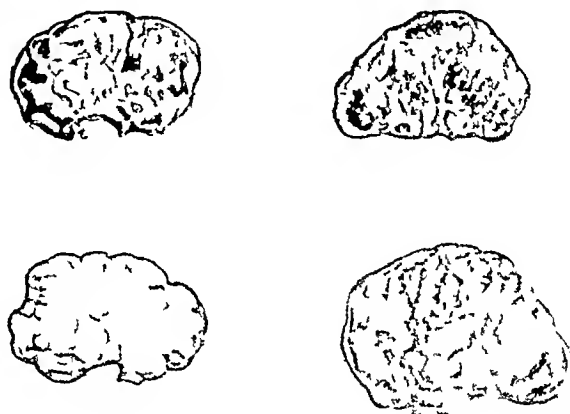


FIG 1

Slices through two benign giant cell synoviomas of tendon sheaths. In each instance the upper slice has been treated to show the Prussian blue reaction and is from the same tumour as the lower (unstained) slice. The lower slices show the rusty mottling due to haemosiderin deposits with opaque yellowish patches of lipid accumulation. The slices to the left show the groove which contained (in this case) the flexor tendon of the affected finger.

Benign synoviomas of joints and bursae usually take the form of plaques in the capsule, but polypoid formations, often multiple, may project into the joints. It is in this variety that the amount of lipid deposit is greatest and the histological structure becomes simply an accumulation of foamy cells held together by a delicate collagenous and vascular framework. In chronic villous arthritis on the other hand, the villi, though sometimes of a rich brown or chocolate colour from massive haemosiderin deposits, seldom contain any appreciable amount of lipid.

## HISTOLOGY

The microscopic structure of the benign giant-cell synovium is usually unmistakable. The fibrous stroma, of variable density and amount, is collagenous and often much hyalinised. In the interstices lie small groups of polygonal cells, arranged either in small masses without intercellular fibres or lining small spaces. Associated with these cells of frankly lepidic\*

[\* Lepidic refers to the tissues of lining membranes characterised by the absence of definite stroma between individual cells.—EDITOR.]

character (and probably derived from them by fusion) are variable numbers of multinucleated giant cells, similar in appearance to osteoclasts or foreign-body giant cells. Large areas of the tumour may be almost completely fibrous, other areas are richly cellular, including both numerous giant cells and lepidic cell-groups.

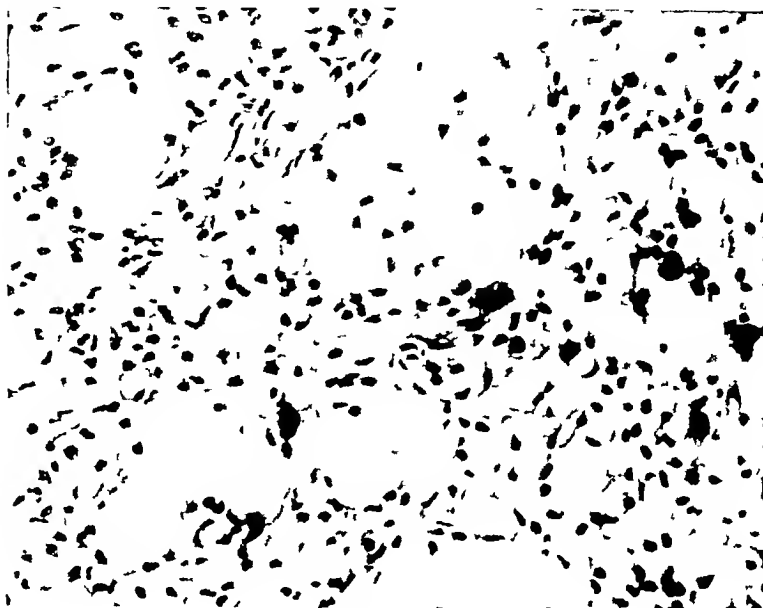


FIG 2

Section from one of the xanthic areas in the larger of the two tumours in Fig 1, showing numerous foamy cells of neoplastic origin

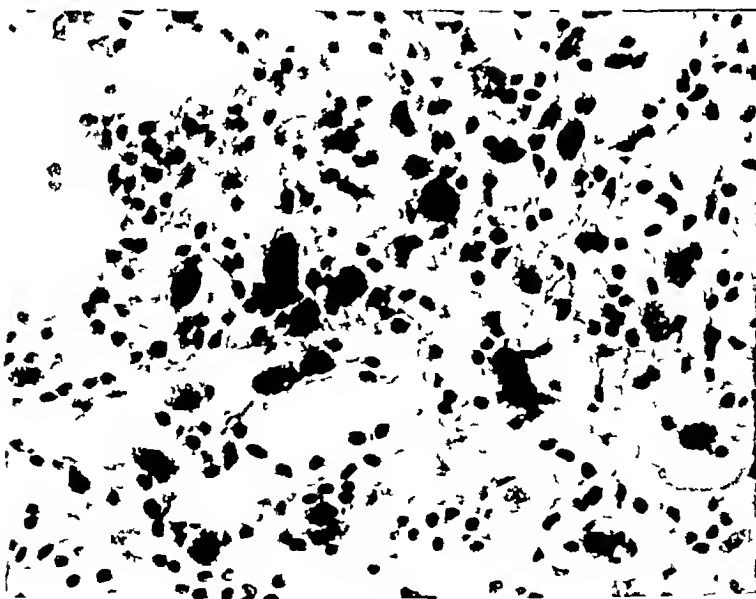


FIG 3

Section from one of the areas of rusty mottling in Fig 1 showing many of the tumour cells charged with haemosiderin granules

The resemblance to osteoclastoma is remote indeed. That the glandular spaces are usually devoid of mucoid content is I think the only objection to regarding them as of synovial origin. By contrast, the most characteristic examples of malignant synovioma often show mucicarmine-staining material in such alveolar spaces as are present.

In benign synovioma the deposition of lipoid and of haemosiderin are secondary phenomena. Lipoid is deposited in consequence of necrobiotic changes in tumour tissue over the course of months or years. The deposition of haemosiderin is due to siderosis from traumatic effusion of blood. Both the lipoid and the haemosiderin may be taken up by the

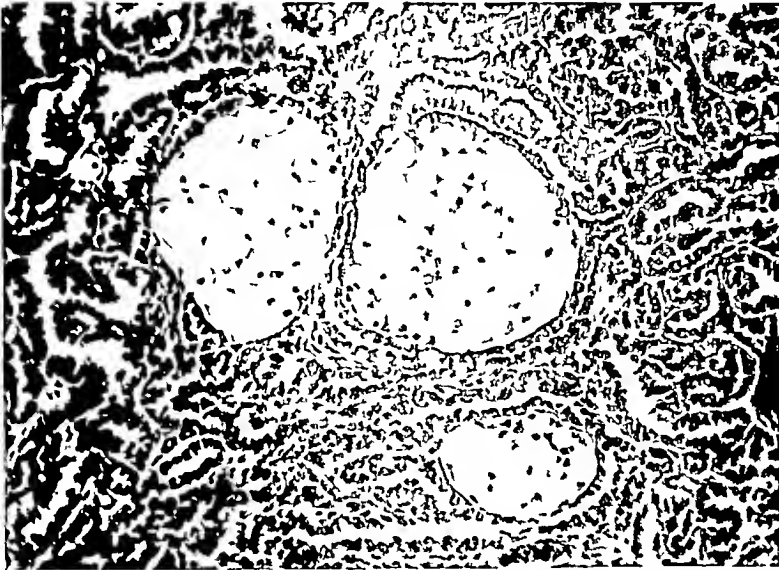


FIG 4

An adenopapilloma of the kidney showing focal accumulations of non-neoplastic foamy cells within the stroma



FIG 5

Xanthomata of choroid plexus of the lateral ventricle. The lesions were symmetrical (Magnified  $\times 3$ )

essential tumour cells (Figs 2-3). These being synovial, and therefore no more than differentiated histiocytes, still retain many of the more primitive functions of the latter, including phagocytosis. Other non-neoplastic macrophage cells of histiocytic, fibrocytic, or endothelial type are also concerned in the process.

### The so-called "Xanthoma" Cell

The occurrence of cholesterol fat in tumours is often observed, but its significance has been misinterpreted. Cholesterol fat is sometimes present within the tumour cells themselves, apparently as a functional manifestation. Examples of this are seen in renal carcinoma of the hypernephroma type, in adrenal cortical adenoma, and in certain types of ovarian tumour. Many fibrous tissue and endotheliomatous tumours of the skin, mostly benign and of slow growth, assume to the naked eye a yellow colour owing to a proportion of the tumour cells undergoing this "xanthic" change. In other instances tumours become infiltrated focally with lipid-filled non-neoplastic phagocytes. Infiltration of this type is common, especially in tumours of slow growth where slow necrobiotic changes occur from a deficient blood supply. The lipid taken up by the phagocytic cells is derived from disintegrating tumour tissue, extravasated blood, or secretory products. The commonest examples are adenomas of the thyroid, adenopapillomas of the kidney (Fig 4), and the more slowly growing neurofibromas (for example of the acoustic nerve), but all sorts of tumours may show this secondary change.

In the benign giant-cell synovioma both types of cell, neoplastic and non-neoplastic, may be concerned in this phagocytic process, as also in the phagocytosis of haemosiderin. In certain articular synoviomias the amount of accumulated lipid may be very great and it is to such tumours that the term "xanthoma" has often been applied.



FIG 6

Bilateral xanthomata of choroid plexuses. Specimens from two cases. (Natural size.)

Many writers do not yet realise that the term "xanthoma" is a misnomer. It is no doubt convenient to apply the suffix "oma" in this loose way to any sort of mass or lump (for example granuloma, syphiloma, and tuberculoma), but it should never be so used except on the clear understanding that it does not imply neoplasia. In the three instances quoted no difficulty arises, their non-neoplastic nature is clearly understood. The term "xanthoma" however, is in a different category, because it has been applied not only to frankly non-neoplastic conditions like the cutaneous xanthoma of hypercholesterolaemia and to "xanthomas" of the choroid plexus (Figs 5-6), but also to genuine neoplasms of various kinds in which the presence of lipid is entirely a secondary phenomenon.

It must be insisted that there is no such thing as a xanthoma in the neoplastic sense of the term any more than there is a neoplastic "tuberculoma" or "sideroma". Twenty-four years ago (Stewart 1924) I endeavoured to introduce the term "xanthosis" on the analogy of "siderosis" to cover this condition of infiltration by cholesterol fat whatever the nature of the cells involved. The seed fell on stony ground.

It is still more unfortunate that "xanthoma cell" should have established itself in our terminology. There is no such thing as a specific xanthoma cell. As I have indicated, many types of cell are capable of becoming charged with cholesterol fat—histiocytes and fibrocytes, serosal, endothelial, and synovial cells, renal epithelium and microglia, not to mention cells of the adrenal cortex, corpus luteum and sebaceous glands, and probably other cells whether

healthy or diseased. In America, certain writers now speak of pseudo-xanthoma cells when, I gather, they mean no more than lipid-filled phagocytes. Thus they imply that there is such a thing as a specific and presumably neoplastic cell to which alone the term xanthoma cell is strictly applicable.

All lipid-filled cells, whatever their nature, are recognisable in paraffin sections by virtue of the foamy cytoplasm, and in fresh frozen sections by the content of doubly refracting cholesterol ester droplets. Their true nature, whether neoplastic or otherwise, can be determined only by other histological characters and by anatomical arrangements and relationships.

The prefix is correctly used in "fibro-xantho-endothelioma" and "xanthic neurofibroma". No doubt "xanthoma" will continue to be used as a convenient name for the infiltrative cutaneous lesion which results from hypercholesterolaemia, and for the "pure" xanthoma of the choroid plexus (usually bilateral), which also is a simple infiltration by "foamy" cells, but there must be no implication of neoplasia. The terms "xanthoma cell" and "pseudo-xanthoma cell" should be dropped.

#### SUMMARY

Benign giant-cell synovioma, the most frequent example of which is the well-known myeloid tumour of tendon sheaths, is used as a text for the discussion of the true significance of the so-called "xanthoma" cell. These cells are the result of the phagocytosis of cholesterol esters and are of varied histogenesis. Some are undoubtedly of neoplastic origin, most of them are not, being usually histiocytic, fibrocytic, serosal or endothelial. There is no such thing as a specific xanthoma cell.

The term "xanthosis" might well be used to designate this process of infiltration of tissue with cholesterol fat, and the prefix "xantho-" or the adjective "xanthic" in tumour terminology, as for example in "fibro-xantho-sarcoma," "xanthic neurofibroma," and so on.

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# RUPTURE OF EXTENSOR TENDONS BY ATTRITION AT THE INFERIOR RADIO-ULNAR JOINT

## Report of Two Cases

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Ruptures of tendons by attrition, such as those of extensor pollicis longus and the long head of biceps brachii, are well recognised. References abound in the literature. But a search through the quarterly *Index Medicus* over the past thirty-one years reveals no direct reference to rupture of the extensor tendons of the fingers by attrition at an arthritic inferior radio-ulnar joint. Nor was any account traced in standard text-books. References in articles under other headings may of course have been missed, but the condition would seem to be sufficiently unusual to justify the record of two cases.

**Case 1** E B, a labourer aged fifty-seven years, first attended the London Hospital on March 15 1946, complaining that three months earlier, without any injury that he could recollect, he had abruptly and painlessly lost the power of extending his left little finger. One week later, in an exactly similar manner, he lost the power of extending the left ring finger and noticed a lump towards the ulnar side of the dorsum of the left hand.

On examination there was inability to extend the metacarpo-phalangeal joints of the ring and little fingers and a small nodular elastic swelling was present over the dorsum of the proximal end of the space between the fourth and fifth metacarpals. The diagnosis was made of spontaneous rupture of the extensors to the ring and little fingers.

At operation the tendons were exposed through a longitudinal dorsal incision. The tendons of extensor digiti minimi and extensor digitorum communis (IV and V) were found to be ruptured, and their distal ends matted together in scar tissue constituted the swelling which had been noted. The proximal ends were found lying just proximal to the inferior radio-ulnar joint.

The tendon sheaths were visible as attenuated grey strands joining their cut ends. The tendon of extensor digitorum communis (III) had moved ulnarwards into the position normally occupied by the severed tendons and it was frayed half through from its ulnar margin, over a length of one centimetre, exactly level with the inferior radio-ulnar joint. On retracting this tendon laterally, the cause of rupture was at once apparent. In the groove for the tendons was a small rounded hole four millimetres in diameter. When the forearm was pronated and supinated an arthritic roughening of the articular margin of the lower end of the ulna could be seen moving to and fro in this hole, one particularly prominent part of the roughening projected just through the hole into contact with the tendon. The mechanism of attrition was only too clear. (Fig 1)

Three centimetres of the lower end of the ulna was excised. The palmaris longus tendon was exposed but it was found to be too tenuous for use as a free graft and instead a longitudinal sliver of the tendon of flexor carpi ulnaris was taken. It was sutured to the proximal end of extensor digitorum (IV) and to the fused distal ends of extensor digitorum (IV and V) using stainless steel wire sutures.

The hand and forearm were immobilised in a cock-up plaster with the metacarpo-phalangeal joints extended fully and the interphalangeal joints in the mid-position. The plaster was retained for one month by which time moderate power of extension at the metacarpo-phalangeal joints had returned. The patient returned to light work as a night watchman two and a half months after operation.

When seen recently one year after operation, he had complete power of extension of all fingers and no disability. The only abnormality noted was a slight tendency to "bowstringing" of the extensor tendons when the wrist was fully dorsiflexed. (Figs 2-3)

**Case 2** J R, aged sixty-six years, a general repair worker engaged in carpentering and bricklaying attended on September 25 1945, complaining that one month previously he had suddenly and painlessly lost the power of extending his right ring and little fingers. He remembered no recent injury to account for this but recalled that nine months previously the back of his hand had been cut by glass in a bomb "incident". He indicated that the site of this injury was over the shafts of the fourth and fifth metacarpals on the dorsum. No scar was apparent. There was complete loss of extension at the fourth and fifth metacarpo-phalangeal joints but not at the interphalangeal joints (Fig 5). The lower end of the right ulna was prominent, and radiographic examination revealed arthritic changes in the radio-ulnar joint (Fig 4).

At operation findings almost identical with those in Case 1 were revealed, the only differences being that the tendon of extensor digitorum (III) was intact and that the distal ends of extensor digitorum

(IV and V) were not matted together. These tendons had been severed at the level of the inferior radio-ulnar joint by arthritic roughening of the lower end of the ulna which had worn a hole through the capsule and into the floor of the tendon groove under the dorsal carpal ligament. After removal of the lower end of the ulna the severed tendon ends were mobilised and united by two free tendon grafts using a

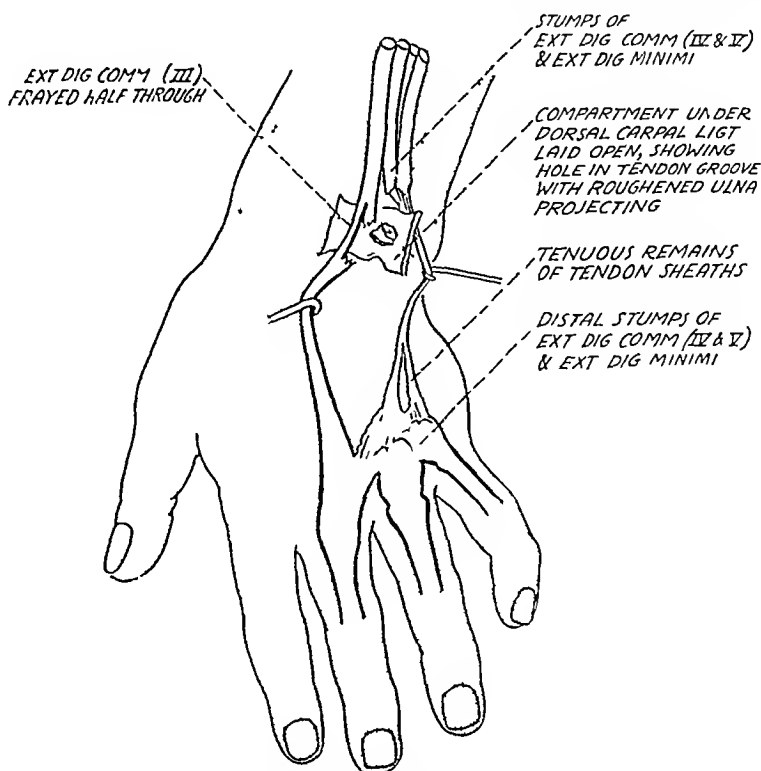


FIG 1

Case 1. Attrition rupture of extensor tendons due to arthritis of inferior radio-ulnar joint. Sketch of essential findings at operation.



FIG 2

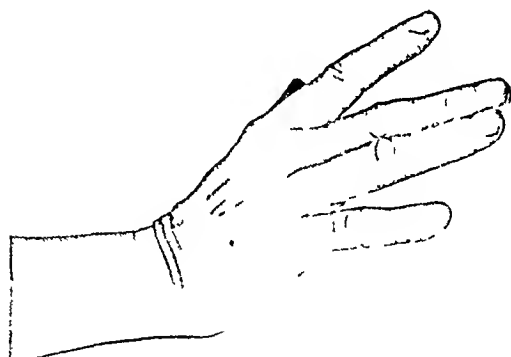


FIG 3

Case 1. Left hand after operation (Fig 2) showing that a full range of extension movement was regained despite slight bowstringing of the tendons at the wrist in dorsiflexion. Fig 3 shows the normal right hand for comparison.

length of palmaris longus tendon and a longitudinal sliver of the tendon of brachioradialis. Stainless steel wire sutures were employed. A cock-up plaster was retained for three and a half weeks, after which time active movements of the metacarpo-phalangeal joints were started. Five months after operation the patient had full use of his hand but showed a slight degree of extensor lag in the fourth and fifth fingers. This lag persisted when he was seen one year after operation but it caused no disability whatever (Fig 6).

The similarity of the pathological picture in these two cases indicates that this type of attrition rupture is a real, if unusual, entity. Indeed it is remarkable that it should be so rare as seems to be shown by the complete absence of reference to it in the literature.



One other point of interest in both operations was the successful use, as a free graft, of a longitudinal strip cut from the margin of a tendon without impairing its continuity. Admittedly this procedure is not to be advocated widely because in general there is an

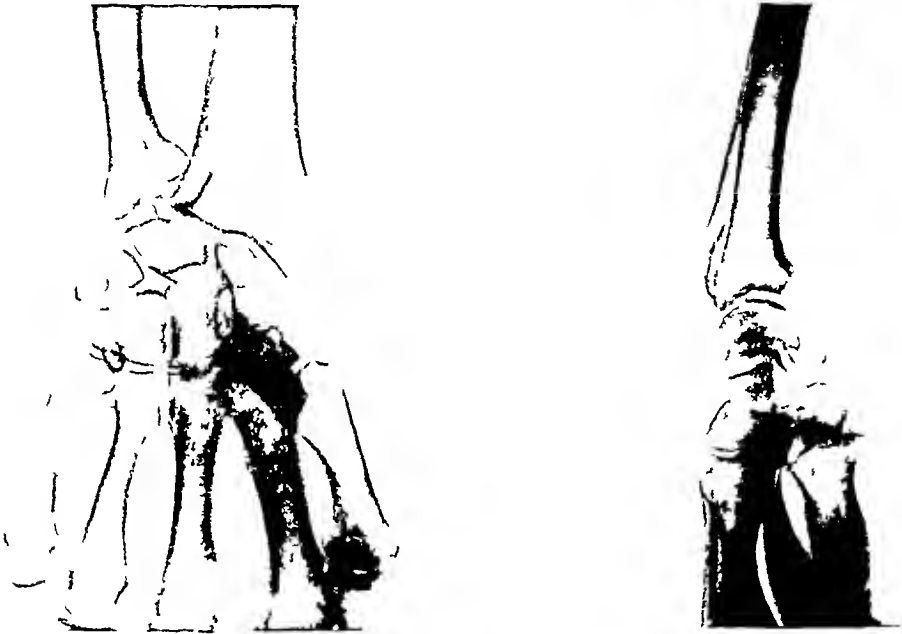


FIG 4

Case 2 Radiographs of the wrist joint showing osteoarthritis of the inferior radio ulnar joint with lipping and arthritic roughening of the joint margins



FIG 5

Case 2 before operation showing loss of extension of the ring and little fingers



FIG 6

Case 2 after operation showing slight extensor lag in the ring and little fingers

abundant supply of tendons which can be sacrificed to serve as whole tendon grafts. But at least it is shown that such part-tendon grafts can succeed.

In conclusion I would like to express my gratitude to Sir Reginald Watson-Jones, under whose care these patients were admitted when I operated upon them, and for his encouragement to publish this account.

# RECURRENT POSTERIOR DISLOCATION OF THE SHOULDER JOINT

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*From the Orthopaedic Department of the Sheffield Royal Infirmary*

Recurrent posterior dislocation of the shoulder joint is unusual. Bankart (1938) reported one case and Watson-Jones (1943) two cases. Rowe and Yee (1944) reported two cases with defects in the posterior capsule immediately distal to the labrum, but with no detachment of the labrum itself. Hindenach (1947) described a case in which the posterior part of the capsule was very lax, there was no detachment of the labrum. The condition is so rare as to justify the report of a case in which a capsular defect was easily demonstrated and the mechanism of injury was clear.

**L. A. B.**, aged 34 years, was admitted to the Royal Infirmary, Sheffield, under the care of Mr F. W. Holdsworth, on March 22, 1948. He complained that the right shoulder repeatedly "went out of joint." In 1933 he was in the Army, and being an enthusiastic boxer he was sparring with the light-weight champion of Great Britain. In this unequal contest he retreated until his back was against the wall-bars, whereupon the champion delivered a heavy blow to the front of his right shoulder, knocking the head of the humerus directly back from the glenoid fossa of the fixed scapula. The dislocation was reduced under anaesthesia. After this injury the joint redislocated on many occasions. Displacement always occurred when the limb was directed forwards. The patient learned to reduce the dislocation himself. Operations were performed in 1934 and 1936, but neither prevented redislocation. From the position of the scars it seems probable that the operations were a Henderson sling and a Clairmont muscle transplant.

**Clinical examination**—There were three scars in the region of the right shoulder—two five-inch vertical scars in the line of the anterior and posterior borders of the deltoid muscle and a three-inch curved scar directed outwards from the tip of the acromion process. There was also a longitudinal scar on the lateral surface of the right thigh. The patient could dislocate and reduce the joint. If he flexed the limb to the horizontal position, and jerked it backwards in its long axis, the head of the humerus displaced below the spine of the scapula. The limb was fixed rigidly in this position of 90 degrees flexion until the patient jerked it forwards and thus reduced the dislocation. Radiographs in the reduced position showed no abnormality of the glenoid or humeral head, in the dislocated position there was backward displacement of the head in relation to glenoid.

**Operation**—On March 24, 1948, through a five-inch "sabre-cut" incision centred over the tip of the acromion process, the central half of the deltoid muscle was divided half an inch from the clavicle, acromion process, and spine of the scapula. The muscle was turned down in order to expose the supraspinatus, infraspinatus, and teres minor tendons which were divided at right angles, three-quarters of an inch from their insertions. The capsule was divided in the same line for one and a half inches. On retracting the flap of capsule backwards, and the head of the humerus forwards, the lesion was at once apparent (Fig. 1). About one-third of the circumference of the labrum was detached from the posterior part of the glenoid margin. There was abnormal laxity of the posterior part of the capsule of the joint. The gap between labrum and glenoid measured not more than a quarter of an inch. The head of the humerus showed no defect. After dissecting the capsule from the supraspinatus, repair was effected by reattaching the labrum with three stout catgut sutures to the periosteum in the

region of the glenoid fossa. The capsule was then plicated behind the labrum. The capsule, and the tendinous cuff of the supraspinatus, infraspinatus, and teres minor muscles were sutured. The deltoid muscle was reattached and the skin was sutured. The limb was bandaged to the side. Progress after operation was uneventful.

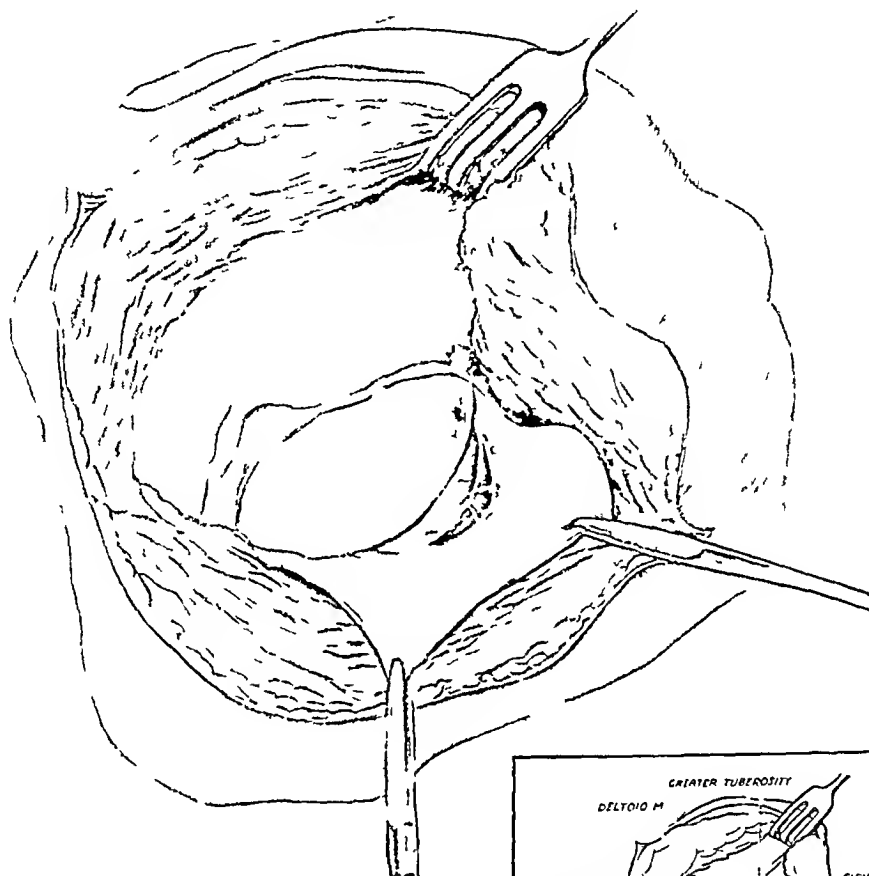
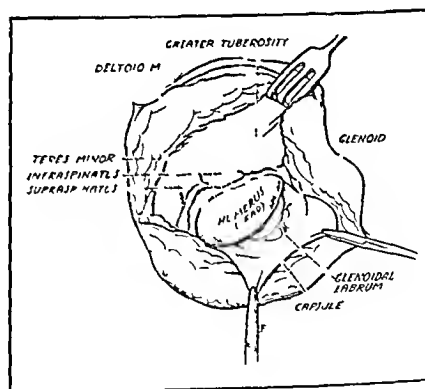


FIG 1

Recurrent posterior dislocation of the shoulder joint, showing detachment of the labrum from the posterior part of the glenoid as seen at operation



I am indebted to Mr F W Holdsworth, F R C S, for permission to publish this case. The figure was drawn by Mr A S Foster.

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### 3 MELORHEOSTOSIS

Synonyms—Léri type of osteopetrosis  
Osteosi eburnizzante monomelica (Putti)

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Melorheostosis is a very rare condition in which certain bones, or parts of bones, are petrosed. It displays striking differences from generalised osteopetrosis or "marble bones". Briefly the distinguishing features are: 1) the changes, in typical cases, are confined to the bones of one limb, 2) the outline of an affected bone is, sooner or later, distorted, 3) there is often pain, occasionally severe, sometimes unbearable, 4) there is limitation of movement in the joints formed by the affected bones. None of these features is invariably present, and each demands further consideration.

Léri and Joanny (1922) published the first case in which an arm was affected, and suggested the descriptive title melorheostosis which is now widely adopted, the distribution of dense areas suggesting to them the flow of candle-grease down the limb. In 1927, Putti described two cases, both with a lower limb affected, under the other descriptive title "osteosi eburnizzante monomelica". More than forty other cases have been reported under various titles, some of which I regard as erroneous. In this country only four unquestionable cases of melorheostosis have been reported (Wakeley 1931, Boggon 1938, Franklin and Matheson 1942, Le Vay 1946).

*Hereditary and familial influences* play no part in this affection.

*Sex*—The condition may be observed in both sexes, males being affected rather more commonly than females.

*Age*—In reported cases the ages varied from five to fifty-four years. If one case is included, in which half the pelvis and the whole of the corresponding femur were affected, the upper age limit is seventy-one years (Rendu and Gay 1929). Three-quarters of the forty-seven cases studied were under thirty-six years of age. It probably begins in childhood in all cases. There is, however, strong presumptive evidence that at least occasionally it begins in foetal life. In three cases deformity of a digit was noticed at birth and this was later shown to be the result of typical hyperostotic changes in certain bones of the hand (Junghagen 1930, Léri, Loiseleur, and Lievre 1930, Widman and Stecher 1935).

*Etiology*—The cause is entirely unknown. Ischaemia secondary to local disturbance of the sympathetic system was suggested by Putti, but the theory which rightly has received greatest support is that it is a developmental error, the result of "embryonic metameric disturbance" (Zimmer 1927).

**Distribution of the petrosis**—The arm is affected less often than the leg, which was involved in three-fifths of thirty-nine monomelic cases. The two lower limbs are equally susceptible, but the right arm is more often affected than the left. Typically the changes are confined to one limb, but search of the literature has revealed seven cases in which more than one limb was the seat of changes strongly suggestive of melorheostosis (though at the time of publication this was regarded as the diagnosis in only four). One of these is certainly atypical and must be regarded as questionable (Hall 1940). The records of an eighth case, as yet unpublished, with both legs and one arm affected, have been examined by courtesy of Dr W Mackenzie. In the seven reported cases, both legs were affected in four, both arms in one, the right arm and leg in one, and all four limbs in one. In the last case it is difficult to avoid the conclusion that changes typical of both melorheostosis and osteopoikilosis were present, though it was reported only under the title of osteopoikilosis (Nichols and Shiflett 1934).

**Symptoms and signs**—Pain is the most frequent symptom. It is complained of at some time in half the cases. The older the patient the more likely is pain to be a feature. The earliest age at which pain was reported was eight years (Putti 1927). The pain is usually dull and aching in character; sometimes it is felt only on exertion; seldom is it severe.

*Limitation of movement* of one or more joints of the affected limb is found in nearly half the cases and is more likely to occur late than early. It is due to the excessive formation of dense bone in the immediate neighbourhood of a joint, and to the deposition of bone in soft tissues, rather than to actual distortion of the articular surfaces. There may be swelling of the limb, oedema, and induration. Erythema of skin over the affected parts of a hand has been reported. Nodular induration of the tissues may be present and, occasionally, irregular thickening of a bone may be felt easily, particularly when the phalanges are affected. Progressive wasting of the limb may occur. Diminished sensibility and tingling have been noted, but only in two or three cases. In one, there was tenderness of the tibia (Nichols and Shiflett 1934).

*Shortening* of the limb has been a feature in some cases (two upper, nine lower limbs), while less frequently the affected limb has been *longer* than its fellow (one upper, three lower limbs).

*Deformities* due to bone thickening, coupled with limited movement of one or more digits of the hand, is not uncommon when the upper limb is involved (seven of sixteen upper limb cases). Pes valgus, genu valgum, curvature of a bone, and enlargement of a knee, have all been reported as being responsible for discovery of the condition of the bone.

Other initial signs and symptoms which called attention to the affected limb were pain, scleroderma, and stiffness. Though in most cases the first complaint is made before growth has ceased, the onset of symptoms may be delayed considerably in spite of advanced changes in the affected bones. There is no undue fragility of the petrosed bones.

**Complications**—*Scleroderma*, with fibrosis and thickening of muscles and other soft tissues, may be responsible occasionally for stiffness. These fibrotic complications, which may precede the bone changes, have sometimes been reported in association with melorheostosis, the soft tissue changes corresponding more or less to the distribution of the bone changes (Gillespie and Sieghing 1938, Dillehunt and Churnard 1936, Clement and Combes-Hamelle 1942).

*Blood examination* reveals nothing of importance. High phosphatase, as in Franklin and Matheson's case, is of no significance.

**Radiographic appearances**—In well-marked cases radiographs show that some parts, and less commonly the whole, of certain bones throughout the length of the limb have the dense, structureless appearance of "marble bones". At first glance the "flow" of dense streaks and blotches—a flow which may be limited to part of a limb, and may be interrupted or continuous—seems to follow the distribution of a main vessel or nerve, even to the finger tips, but this does not bear more close investigation. It is common to see one side of a long bone escape, either for part or all its length, while the other side is dense and thickened. In the forearm and leg respectively it is quite typical to find that one bone is affected while the other is normal. Only very seldom is the flow limited to a single bone. The scapula, or the half pelvis, corresponding to the affected limb usually shows dense patches and spots. Sclerosed bone may be endosteal or cortical, but it is usually present in both situations in a long bone. The later a case is examined the more likely is it that there will be cortical distortion. With few exceptions, dense patches in the carpus and tarsus are entirely endosteal. Cortical thickening and distortion of outline of the affected bones seem to be more common features in the arm than in the leg. In some cases density in a long bone ends above or below in streaks, not unlike those seen in diffuse fibrosis of bone, and these streaks may extend into the adjacent epiphysis. In the epiphyses and short bones the dense areas usually take the form of splashes, streaks or dots. It is quite common, however, and by some it is regarded

as typical, for the region of a joint to be skipped—the earlier the case, the more likely is this to be so. As already stated, the bones are sometimes affected close up to a joint, the movement of which may be restricted.

Curvature, either apparent or real, may be present when one side of a bone is markedly distorted by extensive petriosis. Deposits of bone in soft tissues have been seen in the regions of the hip, knee, shoulder, ankle, and foot. Decalcification of bone in the neighbourhood of dense areas has been noted, and occasionally cyst-like cavities have been seen near, or even in, a dense patch—sometimes these changes are more apparent than real. Though the density varies in intensity in different cases or in different bones of a case, it is usually uniform and smooth.

The skull, spine, and ribs almost invariably escape—but all were affected in Franklin and Matheson's unquestionable case in which the right arm and leg were both the seat of typical changes, and which was remarkable in that the right half of the mandible was grossly thickened and very dense. No other case with involvement of the jaw has been reported. The skull was also affected in two patients reported by Hall (1940), one an atypical case affecting both upper limbs, and the other a case which must, I think, be regarded as questionable. The fourth rib was dense in an arm case of limited distribution (Weil and Weissman-Netter 1932), the sixth rib was involved in Dr Mackenzie's case. The sacrum was affected on one side in a case in which both legs showed extensive changes (Baker and Jones 1941), and in the later films of Wakeley's case, in which both legs were also affected. The patella was affected in at least five cases, and the clavicle only in one.

**Progress**—Probably in most cases the bone changes are progressive—in some this has been proved, as for example in Leri and Joanny's original case which was observed over a period of seven years. Wakeley's case, reported as one of "marble bones," but which I think should be classified as melorheostosis, was re-examined after thirteen years and extension of the lesions had unquestionably occurred. On the other hand the lesions are not invariably progressive—a boy aged five years with a leg affected was re-examined at the age of twelve years and no change was reported (Kibby 1941). Extension of lesions already present seems to be more common than the appearance of fresh areas of density, although the latter may certainly occur.

**Pathology**—Histological reports available in nine cases, some of which are conflicting and not very helpful, indicate that dense areas are the seat of sclerosis, with compact overcrowding of lamellae arranged in a bizarre manner—there is an interlacing pattern of immature and adult bone. Concentric perivascular ossification is sometimes mentioned, and in two cases—but only in two—there was definite fibrosis of the marrow.

**Diagnosis** in a typical case is easy. In generalised osteopetrosis every bone is affected to some extent, and the distribution of the density in individual bones differs markedly from that seen in melorheostosis. From osteopoikilosis the differentiation is also easy, provided that the whole radiographic evidence is considered and that undue attention is not paid to the appearance of one or two epiphyses. Osteopoikilosis is a general affection of the skeleton and it is not confined to one limb as melorheostosis usually is, moreover it is never associated with opacities in the soft tissues.

Multiple diffuse fibrosis of bone (polyostotic fibrous dysplasia), and Albright's syndrome, may give in an individual bone an appearance suggestive of melorheostosis, the fibrotic portion of the bone being unusually dense, not cystic, and having an abrupt outline. But in multiple diffuse fibrosis and Albright's syndrome the epiphyses, carpus, and tarsus are not affected, and the dense areas are not so dense and lacking in structure as in melorheostosis. In cases of fibrosis, one or more metacarpals or metatarsals are not uncommonly involved, but they show general enlargement of the shafts which tend to be of uniform density, with

minimal indication of a cortex, while in melorheostosis the change is that of an asymmetrical or local enlargement, with distortion of the surface by intensely sclerotic bone

No difficulty should be experienced in distinguishing the osteopetrosis of melorheostosis from inflammatory sclerosis

Difference of opinion as to the classification of individual cases is bound to occur some times, as it has done not infrequently in the past

I wish to express my thanks to surgeons in charge of the four British cases who kindly furnished me with radiographic and other details

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#### CASE 21—MELORHEOSTOSIS OF ONE ARM

(Fig 66) Woman, aged thirty-nine years. Complained of pain in the left arm for three years. Deformity of the middle finger present for nearly thirty years. Limitation of movement, to varying degree, of all joints of the limb. Patient kept under observation for seven years, changes found to be progressive. (Case published by Leri and Joanny 1922, and Leri and Lievre 1928.)



FIG 66

Fig 66 Case 21. Diagrammatic reconstruction of published films to show distribution of the petrosed bone. Note the involvement of part of several bones and the distortion of their surfaces. The affection of both bones of the forearm is unusual.

## CASE 22—MELORHEOSTOSIS OF ONE ARM

(Figs 67 and 68 ) Adult male Always had swelling on the dorsum of the right hand Complained of stiffness of the middle finger Some limitation of movement of the elbow, wrist, and affected fingers Palpable nodules on the phalanges (Case published by Junghagen 1930 )

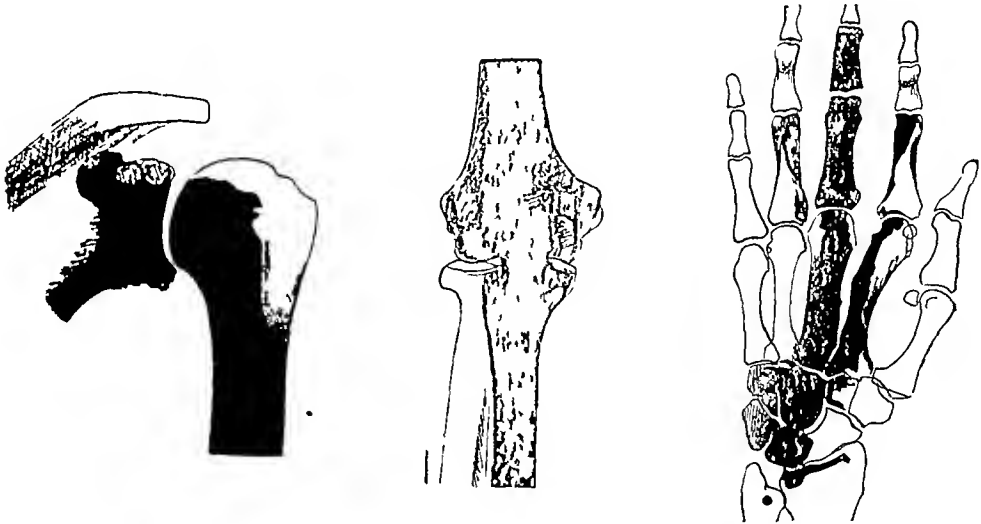


FIG 67

Case 22 Drawings of the published films showing distribution of the flow Note the curious shape of dense bone in the lower end of the radius and the single dot similar to those seen in osteopoikilosis in the lower end of the ulna

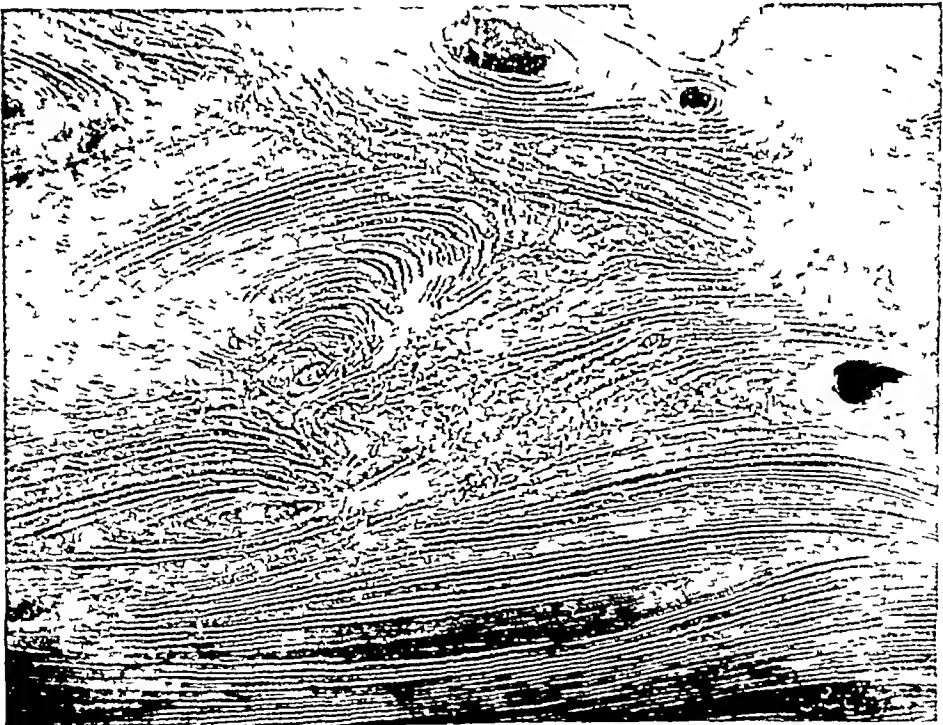


FIG 68

Case 22 Microscopic section of a fragment of the olecranon showing pattern of the sclerosed bone



## CASE 23—MELORHEOSTOSIS AFFECTING ONE LOWER LIMB

(Figs 69-73) Male aged thirty years Complained of ulcers of the right leg and of pain in the right ankle When aged twelve years sustained a fracture of the right foot Served in the Police Force for the past ten years Eighteen months ago noticed swelling on outer side of the right ankle with aching pain in the joint Swelling increased for a year and then remained stationary Has had more pain recently Ulcers on the right leg formed a few weeks before examination Several painless subcutaneous nodules felt in the right leg and thigh Radiographs show typical melorheostosis of the right leg, affecting to a varying extent the pelvis, outer femoral condyle, fibula, astragalus, os calcis, cuboid, outer cuneiform, three outer metatarsals and corresponding phalanges Wassermann and Kahn reactions both positive After antisyphilitic treatment the gummatous ulcers healed rapidly, but there was no change in the bone condition (Report of the case by Boggon in 1938 included no radiographs)

Eight years later the patient reported that the right ankle ached occasionally in wet weather and after a heavy day's work He was still in the police force Radiographs showed slight increase of dense bone over the outer side of fibula above the lateral malleolus, in one metatarsal and in the os calcis and cuboid The calcaneo-cuboid joint was completely obscured A small opacity, seen in an earlier film in the soft tissues near the lesser trochanter, had increased in size Several other opacities, irregular in shape and fragmented, had appeared in the popliteal region The opacities behind the ankle joint, visible when he was first examined, had become more consolidated (By courtesy of Mr R H Boggon and the kind help of Dr W Arklay Steel)



FIG 69

Case 23 Pelvis (1938) showing dense bone in and on the surface of the right ischium and pubis



FIG 70

Case 23 Right knee (1947) showing dense bone in the lower end of the femur one spot in the tibia and a dense area in the fibula which extends into the head of the bone Note opacities in the soft tissues behind the joint



FIG 71



FIG 72A



FIG 72B

Case 23 Fig 71 (print reversed) shows the right foot in 1938 There were irregular dense areas in the astragalus os calcis cuboid outer metatarsals and phalanges Note the distortion of outline of the cuboid and fifth metatarsal and the multiple opacities in soft tissues behind the astragalus Fig 72 shows the same foot in 1947 there is extension of dense bone formation the calcaneo cuboid joint is no longer visible Note consolidation of opacities behind ankle Antero posterior view shows distribution of petrosed bone in metatarsals and phalanges

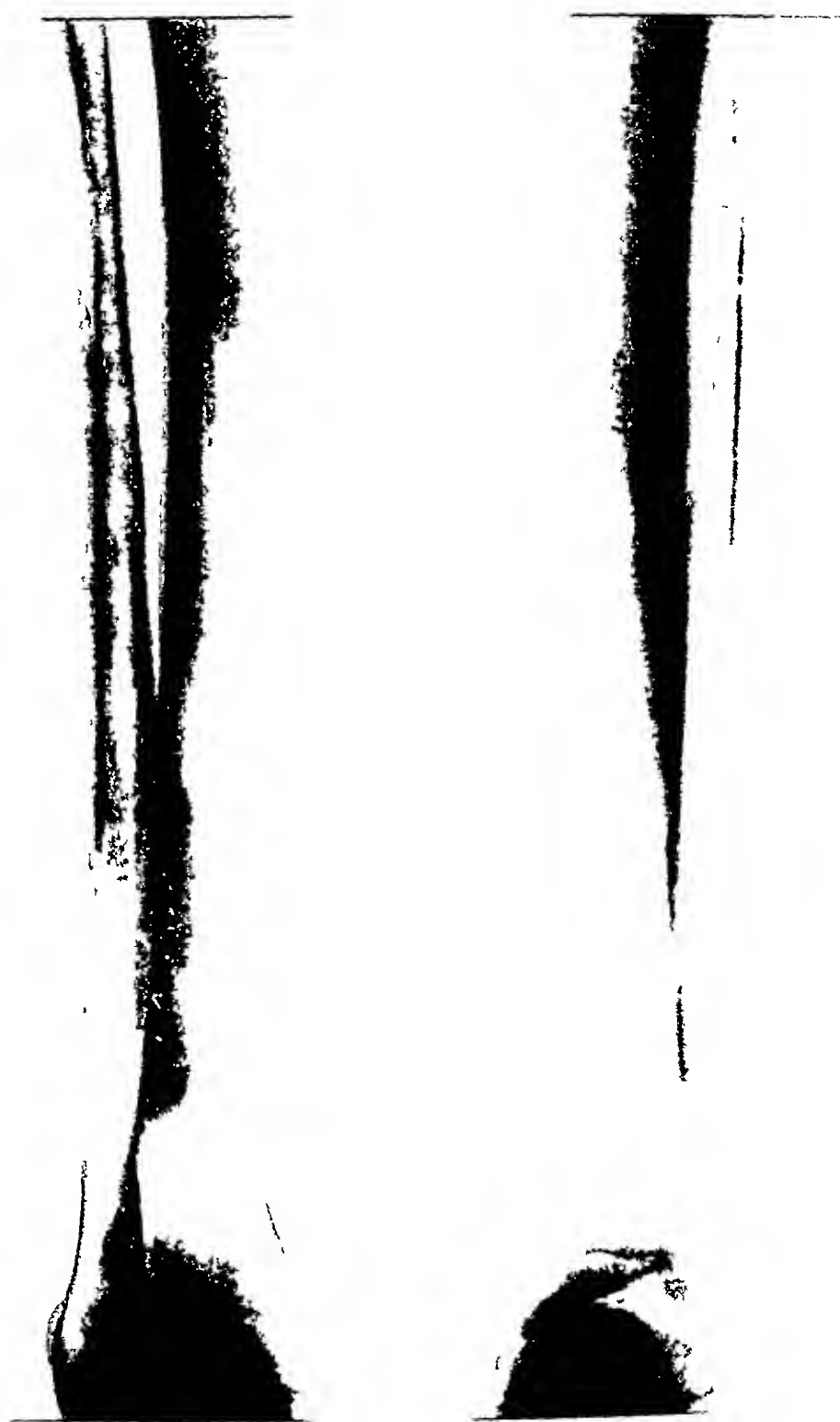


FIG 73

Case 23 (1938) Right and left legs showing marked changes in the right fibula with much subperiosteal hyperostosis. The right tibia is normal, except for a small area in the lower third.

**CASE 24—MELORHEOSTOSIS—Unusual case affecting both lower limbs**

(Figs 74-78) Male aged twenty years No symptoms referable to the abnormal bones Condition discovered at the age of eight years when he was examined for limp due to flat foot No other case in the family Reported by Wakeley (1931) as a case of "marble bones," and by the author (1939) as one of melorheostosis Served in the Royal Air Force Admitted to hospital for injury, re-examined and further radiographs taken in 1944 Lesions in the bones of both legs have definitely progressed The change of diagnosis to melorheostosis seems to be justified (By courtesy of Sir Reginald Watson-Jones)



FIG 74

Case 24 Pelvis and upper femora in 1944 Note involvement of the femoral heads which were unaffected in 1931 Both femoral shafts now show thickening on the outer sides Dense areas in the pelvis have extended and they now involve the sacrum on the right side Note the decalcified areas in the pelvis and in the greater trochanters

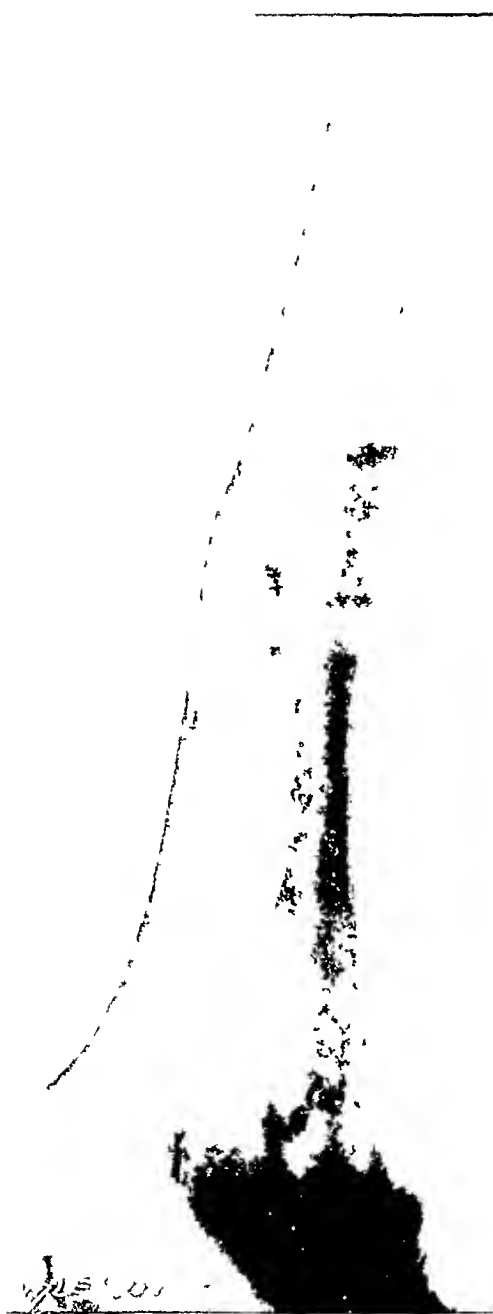


FIG 75



FIG 76

Case 24 Left lower limb in 1944 Fig 75 shows distortion of the surface of the left femur which was not present in 1931 and a streaky arrangement of dense bone towards the lower end. The only lesions in the left leg (Fig 76) are two dense spots in the outer malleolus.



FIG 78

FIG 77

Case 24 Right lower limb in 1944. Fig 77 shows changes in the fibula the tibia being normal. The right knee (Fig 78) shows irregular dense areas in the outer condyle outer tibial tuberosity and head of the fibula.

## 4 OSTEOPOIKILOSIS

### Synonym—Osteopathia Condensans Disseminata

This is an unusual affection of the skeleton characterised by multiple dense spots in many bones. It was first described by Stieda (1905) but is usually ascribed to Albers Schonberg who published a more typical case in 1915. The title now commonly used is derived from the word *l'osteopoeilie*, suggested by Ledoux-Lebard *et al* in 1916. The longer alternative name—osteopathia condensans disseminata—we owe to Wachtel (1921).

*Hereditary and familial* influences are frequently in evidence. It has been observed in three generations (Busch 1937, Hinson 1939).

*Sex*—Males are affected more than twice as commonly as females.

*Age*—It has been found at all ages from foetal life to over sixty years. By some it is thought always to be congenital. Most of the spots, however, are seen in parts of the bones which are certainly not ossified until after birth.

*The cause* is entirely unknown. The affection gives rise to no symptoms and it is always discovered by chance.

*Blood examination* reveals nothing of importance.

**Radiographic appearances and distribution**—The dense spots are circular, ovoid, or lanceolate, the long axis of each being parallel to the long axis of the affected bone. They vary in size between two and ten millimetres. As a rule they are of uniform density but they may have relatively clear centres. They occur particularly in the epiphyses and adjacent parts of the metaphyses, and are plentiful in the short bones of the carpus and tarsus. They vary in number, in most cases they are numerous and are found in every bone with the exception of the skull, ribs, and vertebrae. Even in these bones one or two spots have been seen, the skull being the most unusual site of all. The pituitary fossa is often small and largely covered in by the posterior clinoid processes. The lower jaw is an unusual site for a spot. When present in the spine they are usually in the accessory processes, but they have been observed in a vertebral body. In the pelvis they are common and numerous. In the ilium they are usually congregated near the acetabulum, the sacro-iliac joint, and the crest, leaving the central part of the bone clear.

The spots are in cancellous bone and as a rule they are entirely free from the cortex which is never distorted in any way. Sometimes a spot of dense bone is prolonged into a short streak, in the axis of the bone, especially when it is situated some distance from an epiphyseal line where the metaphysis of a major long bone is passing into the shaft. In the shaft itself spots are seldom seen. These streaks are much shorter, more irregular, and more fluffy in outline than the larger strands of dense bone which are seen in melorheostosis and in some cases of diffuse fibrosis of bone. When the spots are numerous and crowded together, as for example in an epiphysis, the relatively large and irregular dense area thus formed gives the impression of a conglomeration of spots, the apparent fusion is probably due more to overlap of shadows than to actual coalescence.

In the clavicle spots are uncommon, the outer extremity being the most frequent site. In the scapula the acromion is the usual site. In the metacarpals, metatarsals, and phalanges spots may often be seen in the centre of the shafts as well as in the epiphyses.

**Progress**—Cases have been observed over a number of years with no apparent change in the radiographic appearances. In general this seems to be true of patients in whom growth has ceased. Holly (1936), however, claims to have seen spots fuse, others disappear, and new spots develop, especially in children. New spots must appear during growth of a bone to give the appearance seen in adult life.

**Complications**—Several cases have been reported in which the condition has been associated with dermatofibrosis lenticularis disseminata (Buschke and Ollendorff 1928, Windholz 1932, 1933, Svab 1932, Busch 1937, Lindborn 1942)

**Pathology**—On microscopic examination the spots are found to consist of numerous, regularly arranged trabeculae of varying thickness some being thicker than normal, and lying for the most part in the axis of the bone. The general appearance suggests dense spongiosa rather than cortical bone (Schmorl 1931). At the periphery they merge into surrounding cancellous bone. There is nothing to suggest that the spots are endochondral in origin, and they have no connection with epiphyseal cartilage. Occasionally a trabecula is formed around a blood-vessel. There is no sign of fibrosis of the marrow (Schmorl 1931).

**Diagnosis**—In melorheostosis similar spots in the epiphyses, carpus, and tarsus, form a minor feature, but they are more irregular in shape and size and are better described as blotches or splashes than conglomerations of spots. The dense "flow" or broad bands of dense bone in the shafts of long bones determines the diagnosis. In melorheostosis the greater part of a short bone may be occupied by a single patch of dense bone, while in this condition dense spots may be seen in the soft tissues, a condition never found in osteopoikilosis. Cases have been published under one or other of the two titles at the head of this chapter which we would prefer to classify as melorheostosis, and vice versa. In one case (Nichols and Shiflett 1934) the two conditions really did seem to be associated.

Dense spots occur in the cartilage masses of metaphyses in dyschondroplasia, usually when growth is approaching completion in adolescence. Otherwise, radiographs in the two conditions have little in common. For instance in osteopoikilosis the epiphyses are peppered with spots, whereas in dyschondroplasia, though an epiphysis may be mottled, this is never seen without change in the adjacent metaphysis which makes the diagnosis clear. I can see no sufficient reason for regarding the changes characteristic of these two affections, and the marked striation seen in the case published by Voorhoeve (1924), as fundamentally the same, although this was suggested by that author. In 1942 Lindborn reported two cases under the title of striated osteopoikilosis (Voorhoeve). These cases, a brother and sister, are exceptional in many ways and are neither quite like Voorhoeve's case nor like osteopoikilosis. He believed that the disseminated dermatofibrosis which was present in these two children strengthened the concept that the striation is related to osteopoikilosis.

I am much indebted to General J. W. West for supplying me with details of two cases under his care.

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## CASE 25—OSTEOPOIKILOSIS

(Figs 79 and 80) Male aged twenty-one years Condition of the bones, found by chance, when an injury of the knee joint was investigated It is a well-marked case with numerous spots in most bones (Under Maj -Gen J W West)



FIG 79

Case 25 Wrists and hands showing typical dense spots thickly distributed in the lower epiphyses of the radius and ulna and in the carpal bones Note that the spots are seen also at both ends of the metacarpals, and not only in the old epiphyses



FIG 80

Case 25 Pelvis and upper femora showing spots distributed freely in all bones including the sacrum Note that the greater part of both ilia is free from spots



enlarged by the building of an extension of two waiting-rooms, four consulting-rooms, a surgery, and a workshop. The house in Hardy Street was converted into a private hospital of eight beds with a trained nurse in charge. He staffed the workshop with a smith and a leather-worker who were fully occupied in making splints and appliances of his design. Such was the establishment of Hugh Owen Thomas eighty years ago. What other physician or surgeon in Britain thought it essential to have a private hospital and an elaborately equipped workshop whereby to treat his patients and work out his ideas?

It mattered little that he never occupied a resident hospital appointment, or that he was ostensibly in general practice. Three factors accounted for his unique emergence as a surgeon of extraordinary type. First was his ancestral background: he had inherited an unorthodox therapeutic of which he was to be the interpreter. Secondly, the field of his labours was eminently suitable for the application and wide extension of that therapeutic. Lastly, he was fortunate in the timely teaching of John Hilton's "Rest and Pain" which fitted his own conception of the way of cure for bone or joint afflicted with disease or injury.



FIG. 1

11 Nelson Street. On the extreme right is the surgery door with an engraved stone above it marked "H O T Surgerv 1866" (Reproduced from Frederick Watson's "Hugh Owen Thomas" by courtesy of the Oxford University Press)

Like Hunter he had respect for the inherent power of repair possessed by living organisms. To foster this property of tissues he avoided, as he put it, "a hankering to interfere, which thwarts the inherent tendency to recovery." In the treatment of tuberculous joints he believed that the one essential was enforced, uninterrupted, and prolonged rest. He complained that surgeons did not know the meaning of rest, or if they did they were unable to secure it, with the result that many limbs were amputated.

Although for many years he had achieved remarkable results in the treatment of chronic joint diseases his methods were not known until, at the instigation of Rushton Parker, he published in 1875 his first book entitled "Diseases of the Hip, Knee, and Ankle Joints." In this work the now famous hip and knee splints were described for the first time. He had

tried his methods, and carefully checked his results, on more than a thousand patients before proclaiming the principles of his treatment. This publication revealed him as an original thinker in surgery. His appliances were the outcome of much probing of the problems of disease and deformity and of the laws which governed restoration of function. After many trials he simplified the construction of his splints to a single design so that they would "enable any surgeon to treat his cases at home, with no more mechanical assistance than can be rendered by the village blacksmith and saddler." But it is a great error to believe that Thomas was no more than an inventor of splints: indeed he protested against such an estimate of his work. He wrote on fractures and dislocations. By means of fixed traction and the bed caliper splint he achieved in workmen's dwellings such results in the treatment of fractures as were probably unequalled by any other practitioner. No surgeon in England handled so many fractures in one year or devoted such meticulous care to their management. In those days, the fracture was the Cinderella of surgical practice. Rest and alignment were his watchwords. Both were secured by his splints in a day when no X-rays were available.

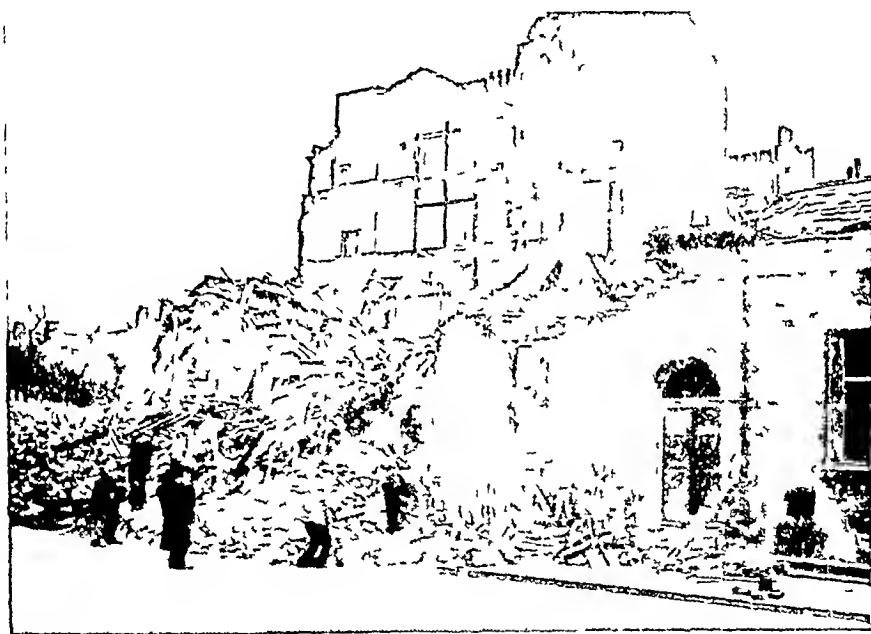


FIG 2

11 Nelson Street after the Liverpool air-raid of May 3 1941. Only the surgery door with the inscription above escaped complete destruction.  
(By courtesy of the Editor of the *Liverpool Post and Echo*.)

In the treatment of infantile paralysis he again insisted on rest, coupled with relaxation of the paralysed muscles. An example of this principle was the cock-up splint he developed for drop-wrist. He introduced many other devices such as the wrench, the cuff and collar sling, the practice of damming and percussing for ununited fractures, and the clinical test for flexion deformity of the ankylosed hip. Once embarked as a writer he issued a series of "Contributions to Medicine and Surgery" which appeared at intervals throughout the rest of his life. All his teaching is embodied in these works but unfortunately they were not well produced, he chose an unknown publisher, they appeared in paper covers, they did not find a ready sale, and his teaching was much less diffused than it should have been. Furthermore he ploughed a lonely furrow and had few professional contacts in Liverpool. There were

discerning surgeons who valued his work—Edmund Owen, Ericksen, Thomas Bryant, and in America—Gibney, and Ridlon who travelled to England to see his work and was amazed at what he saw

Thomas was invited to scientific meetings to disclose his teaching but he could not be induced to leave his practice. For thirty years he took no holiday. His teaching, however, was preserved. In 1864 he married Elizabeth, the daughter of Robert Jones of Rhyd, and was completely happy. They had no children and in 1873 they offered their young nephew, Robert, a home in Liverpool in order that he might study medicine. Uncle and nephew became deeply attached and the younger man imbibed all that Thomas could teach. In later years the disciple became the zealous apostle of Thomas and at last the profession throughout the world became acquainted with his doctrine. Thomas, over-worked, died at the age of fifty-seven on January 6, 1891. The manifestation of grief in Liverpool was astonishing. It was a testimony to "his personal care in the service of his patients." No other pioneer contributed so much in establishing the fundamental principles of orthopaedic surgery.

ARTHUR ROCYN JONES

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## PIONEERS OF OSTEOGENY

### ROBERT NESBITT

JESSIE DOBSON, LONDON, ENGLAND

*Recorder Royal College of Surgeons of England*

Robert Nesbitt, the son of John Nesbitt, a dissenting minister, was born in London, possibly in the year 1700. On September 1, 1718, he began studies as a medical student in the University of Leyden, and attended the lectures of Boerhaave and the elder Albinus.



He corresponded with Albinus for several years after his return to London (see W. R. Le Fanu, in "Janus," 1932). Ten of these letters are in the library of the Royal College of Surgeons of England. He graduated M.D. at Leyden on April 25, 1721, with the thesis "De

partu difficili," and in the same year took up residence at his parents' house in Aldersgate Street, London, practising as a physician. On April 22, 1725, he was admitted as a Fellow of the Royal Society and the next year, on June 25, 1726, was made a Licentiate of the Royal College of Physicians. Two years later he graduated M.D. at Cambridge. He was made a Fellow of the Royal College of Physicians on September 30, 1729, and Censor in 1733, 1738, 1742, and 1745. On March 23, 1741, he was appointed Lumleian Lecturer for five years, he was also a Fellow of the Antiquary Society. He married Miss Deborah Wilkes, whose sister Martha was the wife of James Douglas the anatomist and "man-midwife," the aunt of John Wilkes the politician. Nesbitt died in London on May 27, 1761. His valuable collection of books, 1629 in all, was sold by auction on July 29, and it is of interest to note

that a copy of Vesalius's "De humani corporis fabrica" (1543) was sold for five shillings, a Celsus (1528) for five shillings and sixpence, and "Les Oeuvres d'Ambroise Paré" for two shillings. The copyright of his own book, "Human Osteogeny," was bought by Dr Brisbane for £2, 6s. The sale catalogue is preserved in the Library of the Royal College of Surgeons and Fig 2 is a photograph of the front page.

A reproduction of the title-page of "Human Osteogeny" is seen in Fig 3, and it will be noticed that although the lectures were delivered in 1731, the book was not published until five years later, 1736. In his dedication to James Douglas, his brother-in-law, he acknowledges indebtedness in the following words:

"It was by your persuasions alone that I was prevail'd on to revise, and thus make them public, after they had for some years lain by me disregarded", and further on he makes the following observation:

"As I was, when I drew up these lectures, entirely of your opinion, that little regard ought to be given to any thing advanced in anatomy, which is not demonstrable by proper preparations, I was obliged in order to prove to my hearers the truth of my descriptions, to make a large number of preparations very different from what I had ever seen in any anatomical museum, except that very curious one of Professor Albinus at Leyden." The work is illustrated by excellent plates, the accuracy of which has never been surpassed.

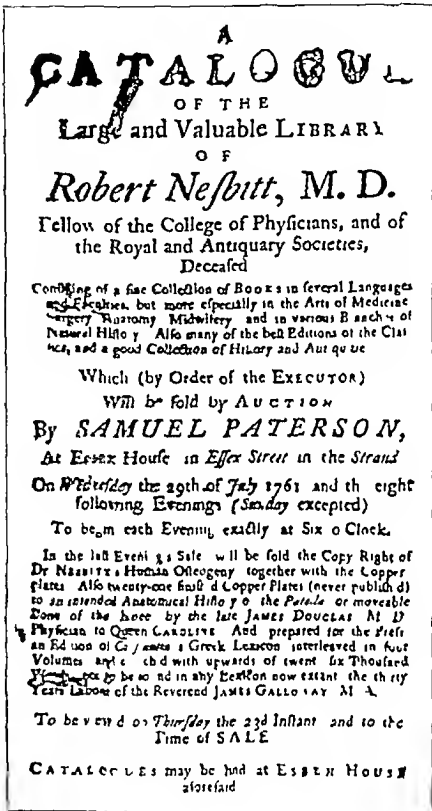


FIG 2

Front page of the sale catalogue of Robert Nesbitt's library which was sold in 1761

It is in these lectures that Nesbitt makes first mention of the formation of bone in membrane as well as in cartilage, but these new ideas did not find their way into anatomical literature for almost a hundred years. Albinus wrote his "Icones ossium foetus humani" in 1737 and in this, his description of the growth of the parietal bone is as follows: "A principio est cartilago tenuis, et valde mollis, membranae cartilagineae simili, in cujus deinde medio os inchoatur, lamella parva, tenuissima, tenera, quae se mox distinguit in fila paullo crassiora. In aliis apparuit tanquam si ipsa cartilago in fila talia ossea abiret. Crescunt haec fila, efformantque reticulum quoddam. Hoc per ambitum fila sua producit, quibus magis magisque praeperens, cartilagem sensim absorbit." Albinus was thus beginning to realise that bone might be formed in two ways, but he failed to appreciate the clear-cut distinction so accurately described by his former pupil, nor does he anywhere mention Nesbitt's work, so possibly their correspondence had ceased long before 1737. "Human

Osteogeny " was translated into German in 1753 by Johann Ernst Greding and published at Altenburg, but contemporary German standard text-books make no mention of it. Haller, however, noted it in his "Bibliographia anatomica" (1774, Vol II, p 286), and remarks of Nesbitt that he was "bonus in universum auctor". In French anatomical literature the first mention of Nesbitt's work and of his theories of bone growth is to be found in Hippolyte Cloquet's "Traité complet de l'anatomie de l'Homme" (Tome premier, p 65), written 1825-27. Here the title of Nesbitt's book is given in English, though the date, 1753, is that of the German translation. References to it in English anatomical text-books do not appear until 1848, in the fifth edition of Jones Quain's "Elements of Anatomy" (Vol I, p cxlviii), where the process is described, with the comment "and so far his views are quite correct".

Quotations from "Human Osteogeny" demonstrate Nesbitt's ideas on the growth of bone. "The bony particles in foetuses begin to be deposited or to shoot either between membranes or within cartilages. Those which shoot between membranes are what form most of the hardest and most solid of foetal bones, and appear much sooner than the others, which compose all epiphyses, and such bones only, whose places are supplied for some time by cartilages which have nearly the same shape those parts are naturally of, when they become bony.

"The texture of that species of ossification, which is produced between membranes, by a careful and proper examination, may be seen to be of small particles, so conjoin'd together, as to form fine bony threads or fibres, which are disposed differently, according to the particular formation of each bone and its several parts. This is most visible in thin and broad bones, especially in some of those, which form the cranium, as you see in the syncipital bone of a foetus about ten or twelve weeks after conception, in which the beginning of an ossification appears now, not as has been generally described to be only in the centre, and from thence to shoot as radii to a circumference, but, as the accurate and great searcher into the secrets of nature, Malpighi observes, it has the appearance of an exceeding fine irregular piece of net-work, the middle of which is much closer and finer than the circumference, and is so thin, that without the greatest care it cannot be taken from between the membrane, which covers it."

With regard to ossification in general, he makes this pronouncement: "What has been now observed concerning the different manners of bony productions, and the phaenomena which are visible during the progress of ossifications within cartilaginous parts, are fully sufficient to prove all bony particles to be originally contained and suspended in the blood, or a fluid secreted from it, which may be called the ossifying juice, much in the same manner as stony and saline particles are very frequently found in some of the most transparent spring waters."

In addition to his clear statement of the two methods of bone formation, Nesbitt gives a logical explanation why some bones are formed in cartilage and some in membrane. The cartilage protects the bone fibres from any impediment or injury they may receive from movement of the foetus or from external pressure. "As for the same purpose nature provides

## HUMAN OSTEOGENY

explained in

### TWO LECTURES,

Read in the *Anatomical Theatre*  
of the *Surgeons of London*

JULY the first and second, anno 1731

In which not only the beginning and gradual increase of the bones of human foetuses are described, but also the nature of ossification is considered, and the general notion, That all bones are formed from cartilages, is demonstrated to be a mistake.

By ROBERT NESBITT, M.D.  
Fellow of the Royal College of Physicians  
and of the Royal Society, and Reader of  
ANATOMY at Surgeons Hall

The main Business of Natural Philosophy is to aquire from  
Phaenomena, without forming Hypotheses, to deduce  
Causes from Effects, till we come to the very first Cause  
which certainly is not mechanical  
Sir ISAAC NEWTON's Opticks Q. xxviii

LONDON

Printed by T. Wood and sold by W. JAMES and R. MANBY  
J. PEARLTON, E. SMITH, J. NOON, and C. DAVIS  
NO. 48, ST. MARK'S LANE

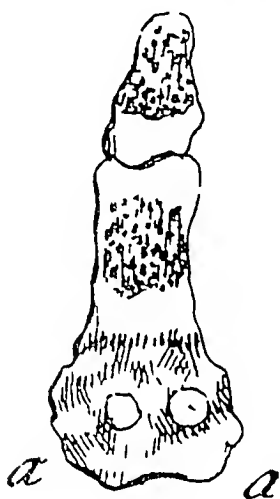
FIG 3

Title page of Robert Nesbitt's *Human Osteogeny* published in 1736



in many parts callus's after fractures, as well as to fix the ends of some bones together, before the bony particles begin to be deposited, because, without such a substance, those particles would continually be subject to have their situations varied, not only by the motions of the part, but also by the constant pressures arising from the different actions of the circumjacent muscles, and consequently their union would be liable to be frequently impeded, and sometimes entirely prevented." Bones formed between membranes, however, have some special supporting or protecting function, and must be established early " For we find most of these bones, even when their ossifications are far advanced, to be either so exceeding thin, or so very small and slender, that a cartilaginous substance of their size could not have much more solidity, than the membranes, between which those bones are produced, and while the foetus

*Fig. 18.*



*Fig. 19.*



*Fig. 18* The bones of the great toe of a full grown *fœtus* slit, with part of the ligament of the joint at the bottom of the first bone, in which are contained two *ossa sesamoidea*, *a a*

*Fig 19* The same bones as *fig 18* of a *fœtus* of six months, with the *ossa sesamoidea*, *a a*

FIG 4

The first accurate description of the sesamoid bones and their growth was given by Robert Nesbitt in his lectures on Human Osteogeny

is so small, the motions of it cannot be sufficient in any degree to impede the natural progress of the ossifications. As for example, we find the clavicles and ribs to be ossified, even when they are so small, that it is demonstrable, from the consideration of the use they are designed for (which is to keep the thorax always sufficiently dilated, and thereby secure the motions of the heart from all manner of impediments and obstructions, they might be liable to from the collapsing of the sides of the thorax by pressure) that no other animal substance but bone of their size could be sufficient to perform that office."

The final paragraph of his first lecture on osteogeny gives a resume of his conclusions " Hence, to conclude, you see by a careful and accurate examination of the various appearances of nature in the bony parts of foetal and young bodies, in what manner it will always be manifest to diligent inquirers, that there is not one single phaenomenon to support the notion of bones being nothing but indurated cartilages, or that they are produced only by a transmutation of a cartilaginous substance. And that there are a sufficient variety of phaenomena to afford autoptical demonstrations, that the blood, or a fluid secreted from it, is capable of producing bony substances, without first forming cartilaginous ones. It likewise appears, that the most material arguments, drawn either from the natural or preternatural effects of

ossification, which have been used to support the common hypothesis, may, with much more reason, be used to overturn it, and to prove that all bony productions, whether natural or preternatural, are caused entirely by the apposition of cretaceous matter, suspended and brought in a fluid to the ossifying part, and there deposited "

An account of the life and work of Robert Nesbitt would not be complete without mention of his original investigations into the mode of growth of sesamoid bones, and the final paragraphs of Lecture II of " Human Osteogeny " gives his theory, which all subsequent research on this subject has proved correct " The only parts of a foetal skeleton, which remain to be taken notice of, are the ossa sesamoidea, which all the writers, I have met with on this subject, have wholly passed over unobserved The number of them in foetuses are, as in adults, very different in different subjects Those, which are the most constantly found, are two in the bottom of the foot, fixt in the ligament of the articulation of the first bone of each great toe, with its os metatarsi In all foetuses, from three months after conception to birth, the places of these ossa sesamoidea are always filled with cartilages of nearly the same shape those sesamoide bones usually have, when they are arrived at perfect maturity, plate vi Fig 18 a a , Fig 19 a a In one subject at birth I found, in each of the sesamoide bones of one foot, a very small point of ossification

" In like manner those ossa sesamoidea, which are sometimes found at the beginning of the musculi gastrocnemii, are to be seen in foetuses By the descriptions I have now given of all the different parts of foetal skeletons, it manifestly appears, that there is not one single bone, except the teeth, or one epiphysis in an adult skeleton, which is not to be found in a full-grown foetus, or in its place a cartilage of nearly the same shape, consequently the account cannot be right, which the ingenious Professor Monro gives of the ossa sesamoidea being ' nothing else than the ligaments of the articulations, or the first tendons of strong muscles, or both, become bony by the violent compression they suffer in the situation they are ' "

The figures mentioned in the above quotation are reproduced here (Fig 4) together with Nesbitt's own explanation of them

The foregoing account of Nesbitt's outstanding discovery of the fact that there are two distinct methods of osteogeny by no means exhausts the claims of his book to a permanent and prominent place in the literature of the subject In its accurate description of the actual stages of the development of the human skeleton, his work as a whole is still unsurpassed

## LUXATIONS OF THE SPINE

WILLIAM BROCKBANK and D LL GRIFFITHS, MANCHESTER, ENGLAND

*From the Medical Library of the University of Manchester*

Surgeons of the sixteenth and seventeenth centuries were greatly impressed by deformity. This is apparent in their books, not only from the greater attention they paid to dislocations than to fractures, but from the many and varied appliances and methods they developed. The main cause of deformity was thought to be "luxation," and under that heading they discussed true dislocations, fracture-dislocations, and many congenital and acquired deformities. In the case of the spine, Pare's great text-book of surgery, published in English translation in 1678, is typical. In this book, spinal "luxation" includes chronic kyphoses and scolioses, the etiology of which, it must be admitted, is often little more clear to day than it was when these deformities were attributed to "defluxions." But let Pare speak for himself.

## "OF THE DISLOCATED VERTEBRAE OF THE BACK"

"The rack-bones of the back may be dislocated inwards, outwards, to the right side and to the left. We know they are dislocated inwards, when they leave a depressed cavity in the spine, outwards, when they make a bunch on the back, and we know they are luxated to the right or left side, when as they obliquely bunch forth to this or that side. The vertebrae are dislocated by a cause either internal or external, as is common to all other luxations, the internal is either the defluxion of humours from the whole body, or any part of them and their ligaments, or else a congestion proceeding from the proper and native weakness of these parts, or an attraction arising from pain and heat. The external is a fall from high upon some hard body, a heavy and bruising blow, much and often stooping, as in Dressers and Lookers to Vineyards, and Pavers, decrepit old men, and also such as through an incurable dislocation of the thighbone are forced in walking to stoop down and hold their hand upon their thigh. But a vertebra cannot be forced or thrust inwards unless by a great deal of violence, and if it at any time happen, it is not but with the breaking of the ties and ligaments, for they will break rather than suffer so great extension. Such a dislocation is deadly for that the spinal marrow is exceedingly violated by too straight compression, whence proceeds dullness and loss of sense in the members lying thereunder. Neither is restitution to be hoped for, because we cannot through the belly, force it into its place, the urine is then suppressed, also the excrements of the belly, sometimes on the contrary both of them break forth against the patient's mind: the knees and legs grow cold, their sense and motion being lost. Such things happen more frequently when the spine is luxated inwards than when it is dislocated outwards."

## "HOW TO RESTORE THE SPINE OUTWARDLY DISLOCATED"

"The vertebrae outwardly dislocated, when as they stand bunching forth, then it is fit to lay and stretch forth the patient upon a table with his face downwards and straightly to bind him about with towels under the arm-pits and about the flanks and thighs, and then to draw and extend as much as we can, upwards and downwards, yet without violence (Fig 1), for unless such extension be made, restitution is not to be hoped for, by reason of the processes and hollowed cavities of the vertebrae whereby, for the faster knitting, they mutually receive each other. Then must you lie with your hands upon the extuberances and force in the prominent vertebra. But if it cannot be thus restored, then will it be convenient to wrap two pieces of wood of four inches long, and one thick, more or less, in linen cloths, and so to apply one on each side of the dislocated vertebrae until you force them back into their seats just after the manner you see it before delineated."

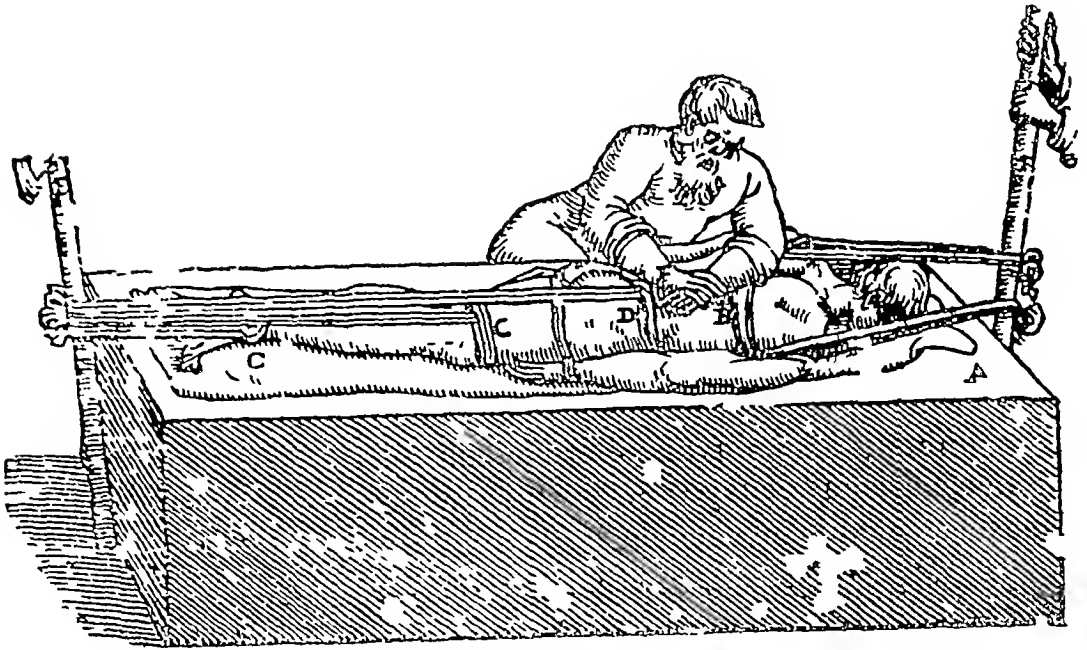


FIG 1

Reduction of a spine outwardly dislocated by traction and direct manipulation  
The illustration is from the 1625 edition of Galen (Vol 4)



FIG 2

A Galenical method of reducing a dislocated spine. It is perhaps noteworthy that the operator has bared his feet! (Galen Vol 4 1625)

"In the meanwhile have a care that you touch not the processes which stand up in the ridge of the spine for they are easily broken. You may know that the vertebrae are restored by the equal smoothness of the whole spine. It is fit, after you have restored it, to bind up the part and lay splints or plates of lead neatly made for that purpose upon it, but so, that they may not press the crests or middle processes of the vertebrae, which I formerly

mentioned, but only the sides, then the patient shall be laid upon his back in his bed, and the splints long kept on, lest the vertebrae shall fall out again "

Pare's dictum of gentle handling " without violence," comes as no surprise from the man who first abandoned boiling oil as a dressing for gunshot wounds His contemporaries were less gentle Fig 2 shows a classical technique for a difficult spinal dislocation, but the brutality of some methods of reducing " idiopathic " kyphosis and scoliosis surpasses even this But first, here are Pare's views on etiology

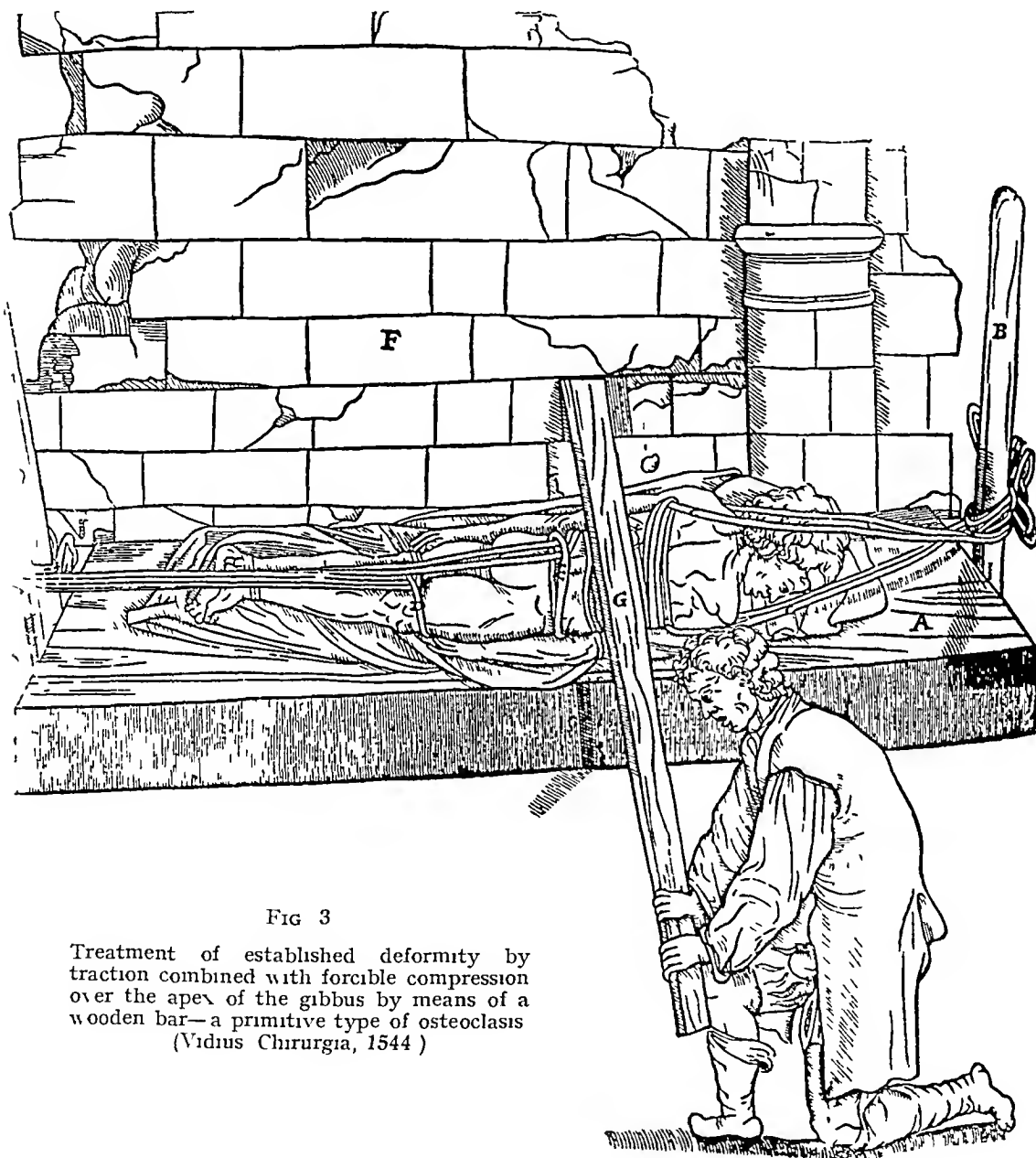


FIG 3

Treatment of established deformity by traction combined with forcible compression over the apex of the gibbus by means of a wooden bar—a primitive type of osteoclasis  
(Vidius Chirurgia, 1544 )

#### " A MORE PARTICULAR ENQUIRY OF THE DISLOCATION OF THE VERTEBRAE PROCEEDING FROM AN INTERNAL CAUSE "

" A dislocated vertebra, standing forth and making a bunch is called in Greek, kyphosis (Those thus affected we may call bunch-backt) but when it is depressed it is named lordosis (such we may term saddlebackt) but when the same is luxated to the right or left side, it maketh a scoliosis (or crookedness) which wresting the spine draws it into the similitude of

the letter S. Soft bodies such as children's usually are very subject to defluxion. Thus nurses when they too straightly lace the breasts and sides of girls, so to make them slender, cause the breast-bone to cast itself in forwards or backwards, or else the one shoulder to be bigger or fuller, the other more spare and lean. The same error is committed if they lay children more frequently or long upon their sides, than upon their backs, or if taking them up when they wake, they take them only by the feet or legs, and never put their other hand under their backs, never so much as thinking that children grow most towards their heads."

Treatment of the established deformity involved reduction by traction, combined with sitting on the apex of the gibbus, or forcing it with a wooden bar—a primitive type of osteoclasis (Fig 3). Vidius (Gundo Guidi 1500?–1568) gives the earliest illustration we have seen of a method involving correction in suspension (Fig 4), but here again the use of a wooden bar is favoured as a help.

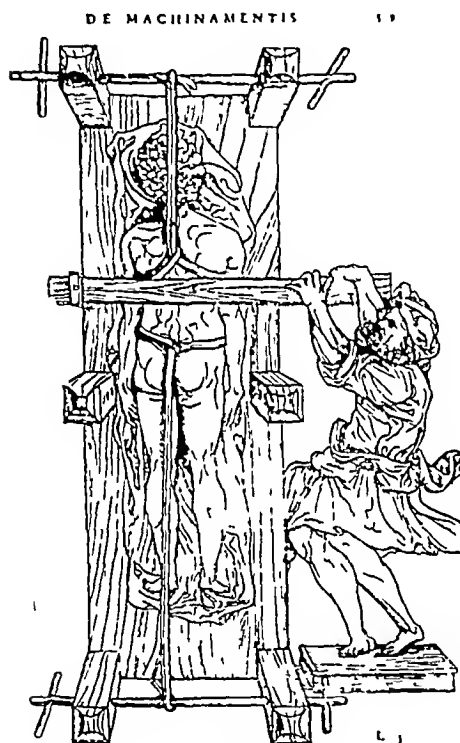


FIG 4

Correction of spinal deformity in suspension (Vidius). The traction-rack is described in detail by Vidius earlier in his book.

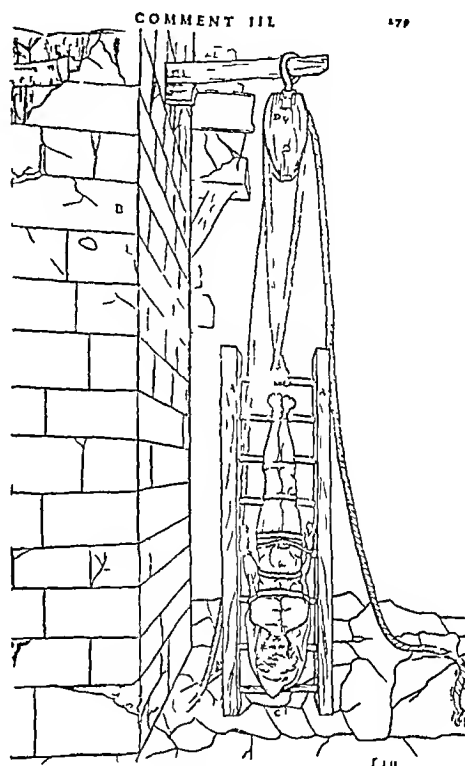


FIG 5

The Hippocratic method of treating spinal deformity which was condemned by Paré (Illustration from Vidius *loc cit* 1544).

No author claimed very good results. "The bunches which have their origin from an internal cause, are absolutely incurable" (Paré). Perhaps that is why he deprecated such bizarre methods as that shown in Fig 5, about which he writes "In the outward luxation Hippocrates commands to bind the man right upon a ladder, the arms and legs tied and bound, then afterwards having raised the ladder to the top of a tower or the ridge of a house, with a great rope in a pulley, then to let the patient fall plumb down upon the hard pavement, which Hippocrates says was done in his time. But I do not shew of any such way of giving the strapado to men. I shew the surgeon in my work how to reduce them surely and without great pain."

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IN MEMORIAM

ROBERT OLLERENSHAW, M D , F R C S  
1882-1948

Of those at the Salford Royal Hospital who were called proudly "the Old Brigade," Robert Ollerenshaw was the last to retire from the active staff. Together with Garnett Wright, J B Macalpine, A A Smalley, Hugh T Ashby, and G J Langley, a glorious team was made up, whose jealousy for the good name of this hospital was the stimulus for long and splendid service in their several specialties.

The keynote to Robert Ollerenshaw's character was his integrity and friendliness, all his actions and relationships were thus to be interpreted. He was big in body and in mind, a true Lancastrian, born in Blackburn, and proud of Lancashire. His father was George Ollerenshaw, J P., of Glossop. He was educated at the Manchester Grammar School and Owens College. Both at school and at the University he played in the soccer first team and secured his "maroon." He was a keen tennis player and until recent years gave many of us a good game.

His love of sport did not prevent him from graduating M B , Ch B in 1905, M D in 1908, and F R C S (England) in 1909. Thereafter he studied in London and Berlin and held resident posts at the Manchester Royal Infirmary and the Royal Liverpool Children's Hospital. He was appointed to the Honorary Staff of the Salford Royal Hospital, the Royal Manchester Children's Hospital, and the Booth Hall Children's Hospital, Manchester.

During the 1914-18 War he served as surgical specialist with the rank of Major in the R A M C. As a student he served as Second Lieutenant in the Cheshire Regiment, and after qualifying became Surgeon-Lieutenant and later Surgeon-Captain in the same regiment.

until the Territorial Royal Army Medical Corps was formed in which he held the rank of Captain. After his war services, which included a term at the 57th General Hospital in France, he restricted his surgical interests to orthopaedic surgery. The department which he established at the Salford Royal Hospital was one of the first in the country. The work that he did, the reputation he attained, and the enthusiasm he engendered in those who were privileged to work with him, are well known. His contributions to the advancement of orthopaedic knowledge include his operation of tendon transplantation for the treatment of pes cavus and an original paper on cysts of the menisci of the knee. In clinical cinephotography he was a pioneer, and with the enthusiastic assistance of his two sons he made the first coloured film of an operation—his treatment for pes cavus. Such was the artistry of the film that no one in many audiences who saw it ever spotted the fact that to illustrate the different stages of tendon transplantation he used two different feet—one right and the other left!

He is remembered by his patients, especially the children over whom he exerted tremendous influence, as a kind and sympathetic friend. His colleagues, members of the Board of Governors, and the administrative staffs of his hospitals, respected him for his ceaseless devotion, they feared him for his candid, yet constructive, criticism, and for his denunciation of sham and hypocrisy, and they loved and admired him for the advice, help, and encouragement which he gave to all who sought his aid. On retirement in 1947 these qualities were recognised by his appointment to the Board of Governors of Salford Royal Hospital. His sudden death, which occurred as we believe he would have wished it, while enjoying an after-lunch game of billiards, has deprived the new Health Service of invaluable assistance. He was intimate with everyone who mattered. He had the uncanny knack of knowing all that was happening. His memory, even for small events and facts, was prodigious—and sometimes embarrassing. We had looked forward to many years of advice from his incisive mind.

Robert Ollerenshaw was a member of many professional societies. He held the office of President of the Manchester Surgical Society and of the Orthopaedic Section of the Royal Society of Medicine. He had been Vice-President of the British Orthopaedic Association and of the Orthopaedic Section of the British Medical Association. When these Associations paid visits abroad he delighted to travel. He was a Fellow of the International Society of Orthopaedic Surgery and an Honorary Fellow of the French Orthopaedic Association. In 1926 he was appointed Clinical Lecturer in Orthopaedic Surgery at the University of Manchester, and for two decades his lecture-demonstrations at Salford Royal Hospital were attended eagerly.

His private life was no less full. By his colleagues, relatives, and friends he was given the nick-names "Bob," "Bob Oller," and "the great white chief," this indicating to some extent his many-sided character and the affection and respect in which he was held. His personality was so strong as to be almost a disadvantage, for it overshadowed his professional qualities to such an extent that even those who were intimate colleagues thought of him first as a man and only then as a surgeon. Whether at work or at play, in private company or public gathering, this rugged, well-built, and handsome man dominated and attracted all about him no matter whether his mood was jovial or stern. His younger days may have been stormy, but his later years unfolded the friendliness which was his real self. No wonder that he gathered about him a close band of friends. Influenced by his love of music and the arts, and aided until her tragic death in 1933 by his charming wife Florence, daughter of Senator Robert Watson of Portage-la-Prairie, Manitoba, his home in Didsbury became the rendezvous of many famous personalities. Among those who were frequent guests were Sir Henry Lytton, Nicol Malko the Russian, and John Barbirolli. His greatest relaxation was the Halle Orchestra, he seldom missed a performance, he was Honorary Medical Officer and a member of the Committee. He was not content only to listen, he played the piano, the 'cello, and the bassoon, and he enjoyed nothing more than to play in an amateur orchestra composed of the family and their friends. "Bob" has left behind him the happiest of memories—a splendid autocrat and a gentleman!

W S C



## PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

This year is outstanding in the annals of the British Orthopaedic Association. A second combined meeting with the American Orthopaedic Association has been held in Quebec joined on this occasion for the first time in history by the Canadian Orthopaedic Association. The meetings were conducted under the leadership of Dr R. I. Harris of Toronto, President of the American Orthopaedic Association, Dr Edouard Samson of Montreal, President of the Canadian Orthopaedic Association, and Mr Alan S. Malkin of Nottingham, President of the British Orthopaedic Association. It is unfortunate that no more than limited British representation was possible, but those who did attend from Britain took with them the good wishes and fellowship of their less fortunate colleagues. The scientific proceedings are summarised in these pages.

The second reason why this is an outstanding year in the history of the Association is that arrangements were made to receive as guests in the American Continent thirteen young orthopaedic surgeons from this country who were appointed as Nuffield and Travelling Fellows in Orthopaedic Surgery and were entertained in the clinics of New York, Boston, Philadelphia, Baltimore, Quebec, Montreal, Toronto, Detroit, Ann Arbor, Chicago, and Rochester. In the editorial of this number of the Journal extracts are quoted from the diaries of these travelling fellows. It is clear that in the course of a strenuous and stimulating tour friendships were sealed. It is hoped and believed that a return visit of young American and Canadian orthopaedic surgeons may soon be arranged and that we may have the opportunity of doing the best we can to emulate the hospitality so generously given to our representatives. We are afraid that we cannot do so well, but we will offer all we have.

### IMPRESSIONS OF ORTHOPAEDIC SURGERY IN THE UNITED STATES AND CANADA

J. CRAWFORD ADAMS, LONDON

*Travelling Fellow in Orthopaedic Surgery*

When Dr R. I. Harris was elected as President of the American Orthopaedic Association in 1947 it would appear that his thoughts turned almost at once to the training of orthopaedic surgeons in Great Britain, the United States, and Canada. He realised that in Britain there were many young surgeons who had been denied the opportunity of studying the development of orthopaedic surgery outside their own country, and that abnormal world conditions made it unlikely that such an opportunity would arise unless special measures were taken. This was the inspiration for his proposal that a group of young British orthopaedic surgeons should enjoy the hospitality of the United States and Canada on the occasion of the combined meeting of the American, British, and Canadian Orthopaedic Associations at Quebec.

That such a project could be brought to reality, and could achieve the success it did, was due almost entirely to the intensive and untiring efforts of Dr Harris, to the remarkable generosity of individual members of the American Orthopaedic Association, and in Britain to the generous help afforded by the Nuffield Trust.

The party was composed of thirteen members—the lucky thirteen—selected from some of the foremost orthopaedic centres of England and Scotland under the capable leadership of Mr Philip Newman. Landing from the Queen Elizabeth on May 12, they were met on the pier at New York by Dr Harris himself. He had travelled more than 400 miles from Toronto expressly for this purpose. After an inaugural dinner he left the party to the hospitality of well-known surgeons who had organised clinical programmes at the eleven orthopaedic centres to be visited. And so the six weeks' tour began. The pace was rapid. It was set on the first day at the Hospital for Special Surgery in New York. Scoliosis was foremost among the many subjects discussed. Succeeding days were spent at the New York Orthopaedic Hospital, the Hospital for Joint Diseases, and the Presbyterian Hospital. Then on to Boston to be charmed by Dr Smith-Petersen, Dr Joseph S. Barr, and Dr William Green, and to see a cup arthroplasty performed by the master himself. At the Children's Hospital discussion on poliomyelitis was both interesting and profitable.

In Philadelphia the dynamic personality and restless energy of Dr Royal Moore was reflected in the closely packed programme which began exactly one hour after leaving an overnight Pullman. It included visits to most of the leading hospitals in the city as well as to that amazing example of philanthropic munificence, the Alfred I. Dupont Institute for crippled children at Wilmington.

In Baltimore and Washington a very slight slackening of pace was acceptable to the British visitors who were unaccustomed to such heat and humidity. Clinical discussions and case presentations were interspersed with country drives, visits to historic monuments, and evening barbecues.

The Quebec meeting was an experience never to be forgotten. For seven members of the Nuffield party it included the honoured privilege—and for some the trying ordeal—of presenting papers before a very distinguished company. At this meeting many recent and happy acquaintanceships were renewed. On June 6 the itinerary led to Montreal where an excellent clinical programme had been arranged by Dr Edouard Samson. It was interesting to note the close similarity of outlook on orthopaedic problems in the great Canadian cities and Great Britain, attributable no doubt to the intimate collaboration, often at the same hospital, between surgeons from both countries during the second World War. At Toronto the proceedings culminated in a memorable dinner at the York Club with Dr Edward Gallie in the Chair. This was the appropriate moment for the presentation to Dr Harris of a gift of old English silver spoons as a simple token of the friendly respect and esteem with which he is held by the Nuffield party.

At Detroit clinical work was thoughtfully curtailed by Dr Mitchell in order to permit a visit to the Ford automobile assembly plant and the unique collection of historic American buildings which have been brought together at Dearborn village. There was Ann Arbor where clinical conferences under the stimulating chairmanship of Dr Carl Bigsley could have been enjoyed for a much longer period than the brief visit allowed. Chicago, tremendous and vital city of unexpected beauty, was enriched by the amazing hospitality of the organising host, Dr Edward Compere. Finally there was Rochester and the great Mayo clinic where a full-time salaried surgical service is seen perhaps at its best. Here is one of the outstanding achievements of medical organisation in which an atmosphere of friendly co-operation and team work has been retained.

The tour is over. We are left with impressions—impressions of the country, the people, the hospitals and the surgery. The vastness of the country is matched only by the immense hospitality of our American and Canadian hosts. This, and the tremendous trouble which clearly had been taken by all concerned in arranging an interesting and representative clinical programme at every centre, left a deep and indelible impression upon the minds of all members of the party.

Although suffering from shortage of beds and a serious nursing problem, the Americans and Canadians are relatively fortunate in the number and quality of their new hospitals. Many of these buildings represent an ideal in structure and equipment which can be no more than a dream in Britain for many years to come. The only criticism we could make was that most hospitals had made little or no provision for individual anaesthetic rooms adjacent to operating theatres.

It was not, however, the purpose of our tour to examine hospital buildings so much as to study the work which goes on within them. The approach to various problems is broadly similar in the three countries with undoubtedly a greater tendency towards operative treatment in the United States. We gained the impression that in some instances this policy was dictated by economic and social factors rather than by surgical considerations. The most pronounced difference of approach was found in the field of bone and joint tuberculosis. In most American centres satisfactory results were claimed from early operative treatment, not only in tuberculosis of the spine but also in disease of the major joints. This is clearly at variance with current British practice. It is obviously desirable that a full scale investigation should be made into this problem, with particular reference to late results, in order that a true assessment may be made of the relative merits of these divergent views.

Much interest was aroused by displacements of the upper femoral epiphysis. In many centres the epiphysis is replaced either by separation through the epiphyseal line or by osteotomy immediately below it. The arguments which were advanced appeared sound and this was borne out by the many excellent results which we saw, in which the hip joint was often indistinguishable from normal. Nevertheless final judgment must be reserved until really long-term results, after the lapse of thirty or forty years, are known in a large series of cases.

A further problem on which profitable discussion took place was that of poliomyelitis. Although no treatment is yet known which will influence the degree of recovery of damaged nerve cells, we were very impressed by the thorough manner in which re-education of convalescent cases was carried out, and we felt that the technique of developing maximal function from such muscle fibres as remained was understood more fully than in most British centres. The problem is of course relatively larger in the United States than in Britain and the popular interest which has been aroused has necessitated the setting up of many special centres.

The difficult problem of scoliosis was of great interest. There is a tendency in larger cities for cases to be segregated in a few hospitals and to be treated by surgeons who have special interest, and who by virtue of accumulated experience have acquired capacity to select the most suitable cases for correction and fusion. The use of giant X-ray films which show the whole length of the spine on a single film is of definite advantage. The turnbuckle jacket is the method of correction usually employed, though at a few centres other procedures are used. At the moment there is no universal agreement as to the length of spine which should be fused.

The system of clinical conferences which has been adopted widely in the United States and Canada has obvious merit in the assessment of difficult cases. Apart from the advantage to the patient, this system has the merit of giving confidence to residents and members of the house-staff in the presentation of cases. It is to be hoped that it will be adopted more widely in Britain.

In seeing so large a volume of work in many cities it was inevitable that certain criticisms should arise. Most of our criticisms were of a minor nature but we would be insincere if we did not refer to one point which concerned us—namely, the question of asepsis in operative technique. We could not help but believe that in clean cases the incidence of suppuration and delayed wound-healing was sometimes higher than it need have been. Perfect aseptic technique is surely of supreme importance, particularly when fractures are being plated deliberately in order to increase the turn-over of beds. We were inspired, one and all, with a determination to increase rather than to decrease the stringency of our own precautionary measures in avoiding wound infection, and to avoid any tendency to place unjustified faith in penicillin and other antibiotics.

By hearing, seeing and discussing the imperfect as well as the perfect, the indifferent as well as the good, our judgment has matured. We have come home with profound respect for the qualities of American and Canadian orthopaedic surgery and for the inspiration and stimulation of American and Canadian surgeons. By knowing the man behind a name his contribution can be better assessed. Herein lies the basis for the unqualified success of a bold venture initiated we believe by Dr Harris, and first discussed in Toronto with Sir Reginald Watson-Jones nearly two years ago. That it will be a landmark in the careers of those of us who were fortunate enough to visit the American Continent cannot be doubted. It is earnestly hoped in Great Britain and particularly by members of the Nuffield party, that within a very short time we may have the opportunity of serving as hosts to the friends and colleagues who were so kind to us in their own country. We cannot hope to measure our hospitality against theirs, but we will do our best.

## IMPRESSIONS OF ORTHOPAEDIC SURGERY IN THE UNITED STATES AND CANADA

JOHN T FAIRBANK, LONDON

*Nuffield Fellow in Orthopaedic Surgery*

It may be presumptuous to formulate even tentative opinions of orthopaedic surgery in the United States and Canada after a visit of only six weeks, but so well organised, balanced, and concentrated was the programme offered to the Nuffield and Travelling Fellows in Orthopaedic Surgery that we gained impressions within that period which under less favoured circumstances might well have taken as many months. When our opinion differed from that of our hosts we were generally in agreement among ourselves but these notes are my own personal impressions formed rapidly, offered with due humility and perhaps without adequate time for digestion and they do not necessarily indicate the agreed opinion of the travellers. No words can ever suffice to express our deep gratitude for all that was done for us and if, in these observations, points of difference have been stressed unduly that is for the sake of interest and it alters our feelings not in the least.

We were very soon impressed by the open and inquiring minds of our hosts. Even the most senior of them, who might well have been forgiven for being set in their ways, showed always a most ready welcome and indeed an eagerness to receive contrary views and to reflect on any criticisms we might offer. For a continent so vast and potentially self-sufficient as North America the extensive knowledge of the literature of other countries and the views of other surgeons held by every member of the team from the most senior to the most junior, was quite remarkable. Nearly every hospital had a medical library—often a very good one indeed.

**Hospitals**—With few exceptions the hospitals are more modern than ours. Although the planning and design may take several years to complete, once a building is started a thousand-bed hospital is finished within eighteen months or two years. Their design differs not greatly from ours except in the comparative smallness of operating theatres, the lack of separate anaesthetic rooms and the absence of large wards—eight beds often being the maximum for one ward in a new building. Air-conditioning and a generous use of sound-proof materials is becoming general. To the Briton, hardened by fuel shortage, the hospitals at first seemed to be unbearably hot although English doctors working in them said that they quickly became acclimatised to it. In hospitals without air-conditioning it was remarkable to see how few windows were kept open, but we were assured that there was no tendency for common colds or other infections to race round the ward, and that post-operative chest complications were seldom seen.

Most hospitals we visited had few non-paying beds. The minimal daily charge was about five or six dollars. This difference from the custom in Britain was very striking, it was perhaps an expression of the higher standard of living and of the lack of private nursing homes such as we use. Even the few larger

wards we saw were occupied mostly by paying patients. The charges were necessarily high so that in general there was an understandable anxiety on the part of patients to return home at the earliest possible moment. For example it was quite usual for a patient to be sent home in a full hip spica or even on a Bradford frame. These economic circumstances and the amount of ill digested medical knowledge available to the public in the lay press are undoubtedly important factors in the general urge which exists towards early operation and in the relatively short period during which conservative methods of treatment are pursued.

**Nursing**—The nursing staff is allotted on a somewhat more generous scale than at home but this is not markedly so having regard to the multitude of small wards and single rooms in which patients are nursed. The nurses are helped by an adequate staff of cleaners. Their training period is more expensive than at home but when qualified they are relatively better paid. Most of them continue to work in hospitals because of course there is little scope for private nursing. Their hours of work are very similar to those in Britain. Technically the nursing is of a high quality but this does seem to be a little at the expense of the human side of their work.

**Clinical notes and Research**—Even in the United States there is some complaint of lack of secretarial help but nevertheless the excellent organisation of note-keeping makes it relatively easy to study clinical surveys. The later follow up work did not always seem as good as ours possibly because of the great distances of travel involved for the patients in attending follow-up clinics. Many hospitals had their own research departments, and the profusion of animal material which was available made it possible for research to be conducted on a far more lavish scale than at home. Such work requires no licence and the conditions in which the animals lived sometimes left much to be desired.

**Surgical and medical staff**—The proportion of medical staff to the number of beds available was much greater than that to which we are accustomed. In some hospitals all the staff were on a full time salary and this certainly led to no lowering of the quality or standard of work or of the inquiring spirit which prevailed. It was nearly always obvious that the seniors allowed their juniors a very loose rein by which to follow their own ideas and yet without loss of the team spirit. We saw little deification of the chief such as exists in continental European centres. Post graduate orthopaedic training struck us as excellent with the possible exception of the undue emphasis occasionally placed on radiographic findings especially in so far as it led to early operative treatment. We attended a number of grand rounds as for example in Toronto where the chiefs of pathological radiological and other services were present. We were very impressed by the way in which every member of the team from the most junior upwards was allowed to and was encouraged to and did in fact express his views.

**Greater emphasis on operative than on conservative treatment**—No inherent criticism is implied in noting the marked tendency towards early operation more particularly in the United States than in Canada, and especially for bone and joint tuberculosis. There is no doubt that this tendency is the result of deliberate choice by surgeons but to some extent their hands are forced by the expense to patients which is involved by prolonged conservative treatment and also by the fact that many patients come not from general practitioners but of their own will already demanding operative treatment and often some specific form of operative treatment. Certainly many patients were saved much time but we were doubtful whether in the long run this really contributed to the advance of medicine. Any new operation which has a sound basis is given extensive trial in several centres so that failings rapidly come to light. The variety of operations swells with great rapidity. Emphasis on the operation as the essential element of treatment has naturally led to great operative dexterity but we were not always impressed with the aseptic technique which almost certainly would make Lane twitch if not turn in his grave.

**Tuberculosis of bones and joints**—Turning to individual subjects the most striking difference from our own ideas was to be seen in the treatment of tuberculosis. Surgical tuberculosis is becoming much less common they certainly see less of it than we do. Tuberculous cervical adenitis is seldom seen and in consequence of most excellent milk control bovine infection is now rare. Little regard is paid to general measures and heliotherapy is seldom used. The whole concentration of treatment is on management of the local lesion.

**Tuberculosis of the spine**—Although in a few centres fixation was used more or less on British lines splintage was usually minimal and in the treatment of spinal caries it was sometimes non-existent. Both children and adults after a few weeks in bed sitting up if they wished were treated forthwith by spinal fusion. Early ambulation was permitted sometimes with no external fixation whatever. Collapse of vertebral bodies was usually accepted as a desirable preliminary to fusion and extension treatment was limited to cases of tuberculosis of the spine with paraplegia. Although at first it must be admitted that we were shocked it cannot be denied that many of the results we saw were excellent—so much so that we soon wondered whether we ourselves were not much too conservative and whether the awful warnings handed down to us at home as to the results of early operation in active tuberculosis did not call at least

for some amendment We felt that the divergence of clinical practice could not be explained solely by differences in the natural resistance of patients or the virulence of bacilli in the two countries Unfortunately we were given no statistical information by which to make proper comparison with our own material

**Tuberculosis of other joints**—These remarks apply equally to tuberculosis of other joints in which the diagnosis was often confirmed by biopsy On occasion the hip joint might be arthrodesed even at the early age of one year and in the knee joint at the age of five years in each case great care being taken to avoid damage to the epiphyseal plates In Boston we were shown convincing radiographs of tuberculous knees in children fused by erosion and the passage of a central graft driven down through a window in the anterior femoral cortex Damage to the *centre* of the epiphyseal plates does not interfere with growth and the cases shown were soundly fused growing evenly and at a rate equal to that of the other limb It was however striking that the tuberculous knee joint in a child even though apparently synovial was at once condemned to ankylosis and the chances of gaining mobility of the joint by conservative treatment were not even considered In Montreal we saw excellent results in a few cases from excision of the humeral head in tuberculosis of the shoulder and a case of tarsal tuberculosis in an adult fused and apparently cured by an extensive operation which in our hands would surely have led to disaster We were told that such disasters from early operation were rare and that the procedure was justified not only by the results and the more rapid recovery but also by diminution in the number of growth inequalities and by the *reduced incidence of general tuberculosis*

**Streptomycin in tuberculosis**—There was fairly general use of streptomycin in these cases This is still in the experimental stage, and not one of our hosts was yet fully convinced that there was gain in so far as healing of the bone lesion itself was concerned There was general agreement that it served as an excellent prophylactic against sinus formation that it enabled operations to be done safely in the presence of sinuses and that it improved immeasurably the chances of success in any attack directed primarily against the sinuses themselves Our impression was that the incidence of severe complications made its use unjustifiable unless sinuses were present but work in the research departments of the Mayo Clinic suggests that streptomycin is generally being used in unnecessarily large doses and that smaller doses may be no less effective and may carry much less risk of eighth cranial nerve palsies and other complications

**Anterior poliomyelitis**—Mastery of the problems of poliomyelitis in the United States and Canada made us realise how much we had to learn, and only a few points can be mentioned In general the existence of muscle spasm has been accepted it is not very common and the degree of spasm varies in different epidemics Splintage was given about the same prominence as in Britain although some schools made extensive use of it in the early weeks Passive but not forced movements were given At the Toronto Hospital for Sick Children a one year's trial of the Kenny treatment had resulted in a higher percentage of deformities There was no general urge to get patients up very early in fact in Baltimore they preferred to keep them in bed as long as recovery in the lower limbs was definitely progressing But once the patient was up there was an early assessment of what his final capabilities were likely to be Treatment was immediately concentrated to these ends Braces were used freely and early Muscle transposition was often employed the biceps femoris (usually alone without semi-tendinosus) was transplanted to the patella and we were shown some excellent results The Billis treatment was assessed at Philadelphia but although some improvement was claimed we were not fully convinced that it might not have resulted from the intensive physiotherapy afterwards rather than from the procedure itself

**Slipped upper femoral epiphysis** was exercising many minds almost every centre we visited had something to say on the subject With one exception, closed reduction except for the most acute cases has been discarded but opinions differed as to the best operative procedure and the best method of internal fixation Some recommended wedge osteotomy of the neck others open reduction through the epiphyseal plate with or without the removal of a wedge of bone while very few favoured subtrochanteric correction They were agreed as to the necessity for some open procedure and the importance of preserving the vessels on the postero-inferior aspect of the neck they were also agreed as to the low incidence of avascular necrotic changes They are tending to operate on cases with slipping of less and less degree and little attention was paid to the possible advisability of leaving alone minor cases which had been present long enough for adaptation already to have taken place between the acetabulum and the femoral head They maintained that with few exceptions movement after operation was greatly improved There was general agreement that the triflanged nail was not ideal for fixation of the head and the promotion of fusion not only because it might cause damage to the blood supply but also because instead of penetrating the bone it might drive the head farther off the neck Various forms of drilling pinning with multiple wires and grafting were advocated but it was obvious that the ideal has not yet been obtained particularly in view of the fact that it is the periphery and not the centre of the plate that should be attacked Opinions also differed as to the importance of promoting fusion on the unaffected side In one series of forty cases thirteen returned within six months to three years with slipping on the other side and the weight of opinion seemed to favour immediate fusion even although no abnormality was apparent

**Scoliosis** was another subject on which we heard much of value particularly in New York. On the whole they tend to operate earlier, and in a rather higher proportion of cases than we do. They watch and assess their patients at six monthly intervals making generous use of 17 inch  $\times$  14 inch films taken in the standing and lying positions. They operate as soon as there is evidence of increasing deformity. There is little faith in the value of exercises except as a general tonic. Great stress was laid on the importance of assessing the total correction obtainable in the secondary curves and of taking care not to correct the primary curve to an extent greater than this sum. Over correction leads to decompensation and pseudarthrosis in the grafted area. We were shown the Milwaukee brace, Von Lickum's transection shift jacket, and Le Mesurier's fish net sling, but although each has its advantages we thought that the best corrections were obtained from the Risser type of jacket. Although most fusions were done in adolescence a number were done much earlier and there was some difference of opinion as to whether growth was or was not affected. We certainly saw patients in whom the normal dorsal curve appeared to be changing to a lordosis and if this be so fusion of the convex side as advocated by Le Mesurier would appear to be logical.

**Bone banks**—The use of the bone bank is spreading fast. The procedure is simple but the necessary deep freeze apparatus is expensive. The temperature which was maintained varied considerably in different hospitals but it is the speed of freezing which matters. The safety of the technique depends upon the care which is taken in aseptic transfer of bone to and from the container. Most surgeons agreed that frozen bone was less effective as a graft than fresh autogenous bone but that it was definitely of value particularly in extensive fusions where the taking of so much fresh bone might be a severe strain on the patient. Phemister however quoted examples where the frozen graft had remained completely unchanged for many months thus leading him to reject the method. Incidentally the beauty of bone preparations at the University of Chicago Clinic impressed us deeply especially the microtome sections covering six or more inches of the head and shaft of a bone.

**Fractures**—In spite of notable exceptions we came away with the impression that a very great deal of hardware was being put into fractures both simple and compound. The results were often good but was it all necessary? We felt that quite apart from medical indications the practice was being dictated by the anxiety to secure X-ray evidence of accurate reduction as a defence against possible litigation and also by the urge to shorten the duration of in-patient hospital treatment. But evidence of the risk of sepsis was there for all to see and one was doubtful whether the student might not gain false impressions as to the need for skeletal fixation.

**Prolapse of intervertebral discs**—The main interest now is turning on the question as to whether or not the spine should be fused at the same time that the prolapsed disc is removed. Although the cases that had been fused gave a slightly higher proportion of excellent results the difference was not so great as to justify routine fusion and efforts are being concentrated on selection of the most suitable cases. At the Mayo Clinic about 40 per cent of all discs operated upon are also fused these including all in which backache is a marked symptom and all in which there is radiographic evidence of narrowing of the disc space or other lumbar abnormalities. We saw many methods of fusion each with its percentage of failures. Most of them aimed at limiting post-operative splintage to a minimum. We liked Chandler's method at Chicago. The method where plates were bolted to the side of the spinous processes seemed rather complicated. We were told by many of our hosts that screws through the articular processes often became loose and sometimes caused nerve root trouble. As in spinal fusions for other conditions great care was taken to confirm that bone fusion was solid by taking radiographs in various positions of flexion of the spine.

**Cup arthroplasty of the hip joint**—The results we saw were most impressive. It was an inspiration to watch Smith-Petersen operating on a very difficult case with easy mastery. We were warned that arthroplasties for old rheumatoid arthritis tended to lose movement after two or three years and might need revision and that it was advisable to warn patients of this possibility. Smith-Petersen laid great stress on the need for slimming the unduly heavy patient and on the importance of continuing exercises for many months or even years. The excellent results we saw were admittedly the cream but all our hosts agreed that even patients with a poor range of movement were usually relieved of pain and it was perhaps for this reason that we heard so little of arthrodesis of the hip joint except in the treatment of tuberculous disease.

**Recurrent dislocation of the shoulder**—After our recent symposium on this subject in which it was agreed that teno suspension operations had largely failed in Britain it was interesting and instructive to learn from Henderson of the good results he had secured. His figures showed successful results in over 90 per cent of cases figures which compare favourably with those of any other method. We must think again. In Philadelphia we heard an excellent and pains-taking paper on age changes in the normal anatomy of the shoulder joint stressing how the tendon of the long head of biceps often pulls the attachment of the glenoid labrum upwards and backwards thus leaving a gap which might be confused with the lesion described by Bankart.

**Congenital dislocation of the hip joint**—Gradual reduction was favoured but methods of holding the limb in abduction and in the required degree of rotation varied widely. There was a tendency to operate earlier than we usually do. We saw cases in which a cup arthroplasty had been done in childhood with good immediate results, the cup being removed about two years after operation. We were much interested too, by Badgley's conception of the etiology of this condition. He believed that ante version was a primary deformity and in considering its development he stressed the importance of the fourth dimension—time.

**Club feet**—In the treatment of club feet the Kite wedged plaster was popular particularly for the fore foot deformity. Most surgeons believed that forcible manipulation was inadvisable at least in early cases. For the correction of the varus heel they liked the Denis Browne splint, but this was extensively modified the side flange being usually very short, and occasionally even placed on the inner side. It was thought that shortness of the tendo Achillis was an important cause of recurrence and tendon lengthening was 'often' done at an early stage.

**Cerebral palsy**—We visited the hospital school at Baltimore developed by Phelps for the treatment of children with cerebral palsy mainly of the athetoid type. Eighty children were looked after by a staff of eighty whose devotion was an inspiration. Of the cases not actually hopeless these children were the worst and although it was admitted that few could be made self-supporting the degree of improvement justified the effort which was required—and it was indeed an immense effort calling for much time, money and concentration of man-power. Phelps does fewer and fewer operations, the whole emphasis being on muscle re-education and relaxation with a generous use of light braces designed to promote gradual stretching at night.

**Amputations**—Both in the United States and in Canada the Stokes-Gritti and Syme's amputations are popular. Syme's amputation is occasionally used even in Buerger's disease. In Toronto we had an excellent demonstration of these stumps and there was no doubt that they had stood up to the stress and strain of life. The prostheses were good and the joints, although perhaps not as shapely as those which can be constructed when the stump is shorter, were inconspicuous and did not display the objections which our limbmakers would have us believe. Much work is being done on suction sockets particularly in the United States and although the fitting has to be done carefully and supervised for a long time the results appeared to be justified.

**Traumatic paraplegia**—We had the pleasure of visiting a number of Veterans and Military Hospitals and were very impressed at the Cushing Hospital, Boston, by the magnificent morale of paraplegic patients, due largely to the excellent entente between doctors and patients. Bed-sores already present on admission as a legacy of earlier treatment were dealt with by various forms of pedicle flap. In the conservative treatment of these sores the frequency of dressing was considered to be important rather than the nature of the dressing. It was believed that every patient could be taught to walk by one or other form of tripod gait. Elsewhere we heard advocates of bilateral amputation in psychologically suitable patients in order to make them more active and mobile.

**Radiology**—All the radiological work we saw was first-class. In New York we saw bone length measurements by the 'scanograph'. At the Boston Children's Hospital in connection with Dr William Green's work on epiphyseal arrest we were impressed by radiographs of the whole limb on outsize films, separate exposures being made over each joint. Most striking also, was the quality of films produced by the 'laminograph'—a modification of the tomograph, in which tube and plate were moved in opposing circles and pivoted so that the central ray followed a cone with its apex at the point under examination. The bone detail shown in pedicles and laminae was wonderfully sharp.

**Pathology**—We heard many excellent papers by pathologists. We became almost familiar with the eosinophil granuloma and the osteoid osteoma. Pathologists and general surgeons talked to us on many problems which were not of purely orthopaedic interest. We were all the better for it.

**Physiotherapy and rehabilitation**—This was of a high order. They have not all the personnel they require, but they are better off than we are and their equipment is superb. In New York we saw reproduced for training every possible function in which a patient might find difficulty. For example there was a bus on the verandah for practice in entering and leaving. The brace shops were excellent. Mass production, and the host of cases they have to deal with have made it possible to gain many advances over our methods. We saw an aluminium caliper joint, said to last about eighteen months and capable of being changed in an hour or so. The artificial hands shown us at Washington made a deep impression. The plastic skin with which they were covered was so beautifully modelled and pigmented that at the range of a yard it was almost impossible to distinguish it from flesh and blood while thumb and index were opposable in the most natural way.

**Summary**—These brief notes cover no more than a small proportion of all we saw. The names of personalities and hospitals have been minimised deliberately because each of them was good, and each gave us food for thought. Time and space will not allow a more detailed diary. To all and particularly to those who inspired this tour, and who gave the funds by which to make it possible we are very very grateful. May a return match soon be played on this side of the Atlantic.



## JOINT MEETING OF THE AMERICAN, BRITISH, AND CANADIAN ORTHOPAEDIC ASSOCIATIONS IN CANADA—JUNE 1948

**Aseptic Necrosis of Bone after Injury**—*Dr Edward L. Compere* (Chicago) referred to aseptic necrosis of large intermediary fragments in double fractures of the shafts of long bones. Serial radiographs showed temporarily increased density; regeneration of bone took place in the same way as that of a bone graft; union occurred but it was usually delayed. *Dr Dallas B. Phenister* (Chicago) in dealing with the management of aseptic necrosis of the femoral head in adults recalled that vascular damage to the bone implied death of overlying articular cartilage. The growing edge of the living tissue which invaded and replaced dead bone was fragile. After six to eighteen months when it reached that part of the head which was opposite the acetabular margin the fragile tissue often yielded so that it was crushed under the stress of weight-bearing. In attempting to prevent this collapse four cases of ununited fracture of the femoral neck with aseptic necrosis of the head had been treated by the insertion of tibial grafts through the neck into the upper part of the head together with threaded wires to immobilise the fracture. In each case transformation of the femoral head took place without collapse but the time was still too short for appropriate assessment. If non-union had existed for more than three years a reconstruction operation or arthrodesis was preferable. *Mr James Patrick* (Glasgow) had treated one hundred and seven recent fractures of the femoral neck by combined nailing and grafting since 1942. The fracture united more frequently than when a nail only was used. In some cases there was late penetration of the graft into the joint. With walking impaction occurred; this caused slight extrusion of a nail but the graft could not behave similarly because by this time it was united with the living distal fragment. From examination of the late results in sixty-three cases operated on more than two years ago it was concluded that the use of a graft reduced the incidence of aseptic necrosis. *Dr W. H. Phummer* (Buffalo) said that symptoms from aseptic necrosis might begin as late as five years after fracture. He demonstrated a light-meter by which to measure the radiographic density associated with necrosis. *Mr H. Jackson Burrows* (London) pleaded for prevention. When cortical bone had been deprived of its blood supply delayed union was inevitable and if there was death of the cancellous end of bone the articular cartilage was destroyed. Little could then be done. Permanent damage had occurred. It was imperative to avoid unnecessarily extensive operations or conversely closed manipulations when open operation would be less damaging. The lesson of gentleness in manipulation had been learned in the case of congenital dislocation and epiphyseolysis but had yet to be learned in relation to fractures of the femoral neck. *Dr Robert W. Johnson* (Baltimore) preferred that channels drilled into the necrotic area should be unobstructed by grafts.

**Subtrochanteric Limb Shortening**—*Dr Lawson Thornton* (Atlanta) described a limb shortening operation which made use of his nail plate. The nail was driven into the femoral neck; the appropriate length of femoral shaft was then excised immediately below the greater trochanter; a spur being left on the inner part of the upper fragment by which to control rotation. The fragments were brought together and fixed by the blade to the nail plate. *Dr Walter P. Blount* (Milwaukee) described similar cases. *Dr J. W. White* (South Carolina) believed that this method had advantages over mid-femoral shortening but he had met the difficulty of delayed union. *Dr Albert Key* (St Louis) emphasized the major character of such operations.

**Osteoid Osteoma**—*Dr Malcolm Dockerty* (Rochester, Minn.) summarised the clinical and pathological features of one hundred and fifty cases. Almost any bone except the skull might be affected. Pain was a constant feature. Microscopically the nidus showed osteoblastic activity and osteoid tissue but never marrow. *Dr T. Campbell Thompson* (New York) emphasized the importance of radiographic control during operation in order to be sure that the lesion had in fact been excised. Radiographic examination of the specimen in the laboratory was also advisable in order to be sure that sections included the abnormal area. *Dr Ralph K. Ghormley* (Rochester, Minn.) agreed that it was difficult to demonstrate the area at operation and yet a patient would be cured. *Dr George E. Bennett* (Maryland) believed that Jaffe's osteoma was no more than Garre's sclerosing osteitis under a new name.

**Slipping of the Upper Femoral Epiphysis**—*Dr S. Kleinberg* (New York) advised multiple drilling of the epiphyseal plate in the management of incipient epiphyseolysis. Weight-bearing should be deferred until there was clear evidence of epiphyseal fusion. *Dr Beckett Howorth* (New York) reviewed treatment in 254 cases. Reduction by manipulation had been possible only if slipping was recent. Operations included attempted manipulative reduction 37, open reduction 35, transcervical osteotomy 7, subtrochanteric osteotomy 10, insertion of bone peg 134. In the last group healing occurred in 131 cases without further trouble. Pegging was the treatment of choice in early stages; drilling without pegging was ineffectual. He advocated early movement. *Dr Clarence H. Heyman* (Cleveland) reported late results in thirty cases re-examined after two years. The radiological result was always good but the clinical result was satisfactory in only seventeen. In eight cases of surgical osteotomy the results were poor; aseptic necrosis having occurred in seven. Cheilectomy of the femoral head in three cases gave



improved function without degenerative changes Ten operations for surgical fusion of the epiphysis in eight patients gave good clinical results *Dr Armin Klein, Dr Robert J Joplin, Dr John A Reidy and Dr Joseph Hamelin* (Boston) discussed correction of the displacement by osteotomy through the epiphyseal line the neck being exposed from the front and care being taken to avoid damage to vessels in the posterior and inferior aspects of the capsule Aseptic necrosis of the epiphysis did not occur *Dr Philip Wilson* (New York) emphasized the importance of early diagnosis and nail fixation He believed that cases which did well after manipulative treatment would have done equally well without it *Dr Albert Key* (St Louis) endorsed the merit of early fixation with a Smith-Petersen nail which should be placed low and far back

**Osteoarthritis of the Hip Joint treated by Arthroplasty**—*Dr Alexander Gibson* (Winnipeg) reviewed 104 cases of vitallium cup arthroplasty of the hip joint He used the Kocher posterior approach Early exercises were facilitated by pulleys rigged on a Balkan frame and were graduated for three stages assisted movements movements from scratch and handicapped movements Weight-bearing was resumed after four weeks Most patients came from long distances and after-treatment was often perfunctory The result was considered good if the patient was earning his own living indulging in moderate physical recreation able to stand firmly on the affected side, and capable of lacing his own shoe it was considered satisfactory if there was no pain a poor result was one in which the patient or the surgeon felt dissatisfied On this basis the results were good 55 satisfactory 21, bad 14 unclassified 14 *Dr Paul C Colonna* (Philadelphia) thought that it would be difficult to deal adequately with contracted soft tissues through a posterior approach and that weight-bearing at four weeks was unusually early *Dr M N Smith-Petersen* (Boston) emphasized the importance of full exposure of the acetabulum which necessitated an anterior approach *Mr K Hampden Pridie* (Bristol) doubted whether the joint resulting from cup arthroplasty would be sufficiently durable to justify this operation in young subjects

**Changes in Elastic Adipose Tissue**—*Dr J G Kuhns* (Boston) classified adipose tissues into those having the simple function of filling and those which took pressure The latter were more resistant to compression and were found in such situations as the heel the ischial tuberosity the patellar ligament the finger tips In the heel fibrous strands passed vertically and could be seen in soft radiographs With advancing age they degenerated became attenuated and broken they were more difficult to delineate radiographically Injury caused distortion of the fibres and loss of elasticity Treatment was manipulative including change of occupation provision of suitable footwear and protective pads *Dr A W Meyer* (Toronto) described in more detail the test-tube shaped tunnels of fibro-elastic tissue found in the heel which could be damaged by injury and also by the irradiation of plantar warts Once the septa broken down pressure caused distortion rather than compression

**Results of Physiological Blocking of Flail Joints**—*Dr Alberto Inclan* (Havana) reported 141 block operations of which 132 were for stabilisation of the ankle joint (102 by posterior block 30 by anterior block) In nine cases a bone block had been performed at the knee joint and in one at the elbow joint In the shoulder hip and wrist joints arthrodesis was considered to be preferable Sixty eight cases had been followed up for periods varying from a few months up to three years The results were reported as excellent 32 good 25, fair 8 poor 3

**Irreducible Congenital Dislocation of the Hip Joint**—*Dr Juan A Farill* (Mexico) from a series of seventy patients with congenital dislocation of the hip joint aged eighteen months to sixty years had selected twelve for operation being careful to exclude those with gross deformity of the femoral head or acetabulum The joint was widely exposed after subtrochanteric femoral shortening reduction was secured in all twelve cases When the acetabulum was shallow an extra-articular shelf was constructed Reduction had been maintained in eleven cases In none was there necrosis of the femoral head The technique of the operation was shown in a cinematograph film *Dr H Rellon McCarroll* (St Louis) and *Dr M N Smith-Petersen* (Boston) urged that Dr Farill's operation was much too drastic

**Arthrography in Congenital Dislocation of the Hip Joint**—*Mr F C Dublin* (Exeter) advocated arthrography as a routine part of the investigation of congenital dislocation of the hip joint, not only to distinguish primary subluxations from true dislocations but also to gain information as to the pathological anatomy and the extent of hypertrophy of the ligamentum teres or interposed limbus which might obstruct reduction Under general anaesthesia three to five cubic centimetres of 35 per cent pyelumbrin or perabrodil were introduced through a fine lumbar puncture needle inserted through a point just below Poupert's ligament half an inch lateral to the femoral artery After manipulative reduction arthrography was repeated in order to confirm that there was no soft part interposition *Dr H R McCarroll* (St Louis) believed that such investigations were of purely academic interest

**Aspects of Metabolic Bone Disease**—*Dr Fuller Albright* (Boston) illustrated cases of pseudo hyperparathyroidism and one example of the Sebright-Bantam syndrome in which there was short stature

a round face, and atypical convulsions. The blood chemistry resembled that of hyperparathyroidism but there was failure to respond to parathormone and yet prompt response to A T 10 (*vide* Endocrinology, 1942 30, 922).

**Oestrogens and Bone Formation in the Human Female**—*Dr Mary S. Sherman* (Chicago) described the hypercalcaemia of ovulation and formation of the egg shell in certain birds. This was not a parathyroid function and ionised blood calcium was unaltered. Intramedullary hyperossification preceding ovulation could be produced by oestrogens. In ovarian deficiency the stature was small and the bone age was retarded. Osteoporosis might result from oestrogen deficiency and their administration stimulated osteogenesis. An obscure case of postmenopausal osteoporosis superimposed upon Paget's disease had been relieved by oestrogen treatment. A woman aged fifty-four years who had undergone panhysterectomy seventeen years before, suffered bone pain and tenderness, tibial bowing, multiple fractures, loosening of all teeth and senile dementia. There was no improvement after parathyroidectomy. Investigation revealed severe osteoporosis of patchy distribution, there was raised alkaline phosphatase but no other blood change. Within a week of administering oestradiol benzoate in doses of 0.3 to 1.6 mg. pain was relieved and extensive re-ossification took place.

**Complete Absence of Ossification in a Stillborn Child**—*Dr Alfred R. Shands, Jun* (Wilmington) reported the stillbirth of a full term foetus in which there was no radiographic evidence of ossification except in the clavicles. The mother was an elderly primipara who subsequently bore a normal infant.

**Treatment of Cervical Fractures and Fracture Dislocations**—*Dr William A. Rogers* (Boston) reported thirty-two patients with cervical fracture dislocations. An emergency collar was used until skull-traction could be applied. In eleven patients traction was continued for ten to twelve weeks, a cervical support then being worn for six to eight months. In twenty-one patients skull traction had been supplemented by fixation of the spinous processes with No. 22 stainless steel wire and by the implantation of bone chips. In these cases skull-traction had been continued for three to five weeks. Twenty-six of the thirty-two patients went back to full work. *Dr W. G. Turner* and *Dr William Cone* (Montreal) reviewed the ten-year results of treatment of cervical fracture dislocations by skull-traction and fusion. Split rib grafts had been used extensively. Thirty-six patients were observed over a period of ten years except one who died from a stroke after seven years. *Mr E. A. Nicoll* (Mansfield) emphasized the fact that function depended upon stability. Factors favouring instability were intervertebral disc damage, rupture of the posterior spinal ligaments and comminution of the vertebral body. Simple compression injuries of vertebral bodies were usually stable and conservative treatment was sufficient. Fracture-subluxations with rupture of the intervertebral disc and of the interspinous ligament could be reduced by extension. Conservative treatment was adequate. Fracture dislocation with locked facets necessitated open operation and grafting. *Dr Carl E. Badgley* (Ann Arbor) drew attention to the danger of extensive oedema of cervical tissues, including the glottis after attempted reduction in late cases. *Dr Paul B. Steele* (Pittsburgh) condemned inclusion of the occiput in high cervical fusion. *Mr V. H. Ellis* (London) stressed the importance of rupture of the interspinous ligaments which often failed to heal thus necessitating wiring of the spinous processes. It was not always sufficient to wire one pair, the interspinous ligament above might also be ruptured. He considered that in some of the reported cases grafting had been unnecessarily extensive. *Dr Rogers* in reply said that the principal reason for operation was inability to restore the lumen of the vertebral canal by other means. The best time for operation was two to three weeks after injury. Which vertebrae to fuse was a matter for careful pre-operative study. *Dr Turner* agreed that cases for operation should be selected carefully. Only twelve of his thirty-six cases had been operated upon but spinal cord lesions did not always brook delay.

**Organisation of an Accident Service**—*Mr William Gissane* (Birmingham, England) reported seven years' experience of organising the Birmingham Accident Hospital which treats 40,000 patients each year. He emphasized the importance of skilled treatment from the beginning. Measures to combat shock should be available in the reception room and when necessary at the site of accident. A mobile unit was used at Birmingham with a team including surgeon, assistant anaesthetist and nurse. Skin grafting was an important measure in the treatment of open wounds with skin loss. In 270 children with burns or scalds necessitating in-patient treatment the mortality rate was 1.7 per cent. The importance of general treatment of ideal conditions for wound dressing and of early replacement of destroyed skin was emphasized. The treatment of hand injuries owed much to Sterling Bunnell. Closed hand infections were treated with penicillin and minimal drainage. Fractures, dislocations and sprains formed the largest group of injuries, visceral injuries formed less than 0.5 per cent. Special units were used to deal with head and chest injuries. *Dr John A. Heberling* (Pittsburgh) also emphasized the importance of skilled treatment of minor injuries, of the value of early skin grafting and the merit of industrial rehabilitation. In treating shock he preferred albumin to plasma.

**Presidential Address**—*Dr Robert I. Harris* (Toronto) recalled that the American Orthopaedic Association was founded sixty-one years ago in the atmosphere of Surgery made possible by Lister. The

Association was eight years old at the time of Roentgen's great discovery. In 1912 Macewen's work on the growth of bone was published. Then had come two wars with great surgical advances. During this time general surgeons had concentrated on the speciality of visceral surgery. There was a common meeting ground in the basic sciences research and teaching. The claim of a special field of surgery carried heavy responsibilities. Advance must be made over a broader front than simple development in technique. There was much to learn from the histology of intercellular substances from the biochemistry and endocrinology of osteogenesis, from the physiology of muscles and muscle fibres and the anatomy of structure and function, and from radiographic studies which might be applied in mass surveys.

**Surgical Approach to the Shoulder Joint**—*Dr Le Roy C Abbott* (San Francisco) illustrated by cinematograph film a comprehensive incision for detachment and downward reflection of the origin of the deltoid. The patient was seated with his trunk at 70 degrees from the horizontal. Operations in which parts of this exposure might be used included removal of calcified deposits from the supraspinatus tendon anterior capsulorrhaphy for recurrent dislocation and intra-articular arthrodesis.

**Anatomical Investigation in Lumbar Disc Degeneration**—*Professor Sten Friberg* (Stockholm) showed radiographic evidence that the vertebral body above a ruptured disc especially the fourth slid forwards on flexion movement and backwards on extension movement. One hundred lumbar spines from subjects aged 10 to 80 years mostly 20 to 50 years had been examined as soon as possible after death. Degenerative changes were in the anterior part of the disc except at the fourth-fifth lumbar level where the degeneration was mainly posterior. In eleven of the hundred cases there was protrusion of one of these two discs. A technique of radio-opaque injection of discs had been devised as a diagnostic aid. *Dr Joseph S Bain* (Boston) considered that despite the importance of degenerative changes acute injury was a significant factor. *Dr Albert Key* (St Louis) did not approve the injection of discs.

**The Use of External Pin Fixation in Late Compound Fractures of War**—*Dr E C Jones* (Hamilton) described forty-one fractures in military patients admitted twenty-four hours to three weeks after injury. twenty-five were compound with varying degrees of infection of the open wound sixteen were closed. External pin fixation with the Stader splint had involved the use of 164 pins. Of these thirty one showed infection of the pin track and eight necessitated operation. All fractures had united except one in which amputation was performed for soft tissue damage and nerve injury. *Dr John R Moore* (Philadelphia) considered that in using external pin fixation three rules should be observed: joints should be avoided there should be no distraction adjacent joints should be splinted for the first few days.

**Treatment of Fractures of the Shaft of the Femur**—*Dr E Harland Wilson* (Columbus) believed that internal fixation with screws and titanium plates was the treatment of choice. He reviewed this method in fourteen cases of fracture and six of operation for limb shortening. Early movements with sling suspension were encouraged. Ambulation with crutches was allowed in younger patients when the knee could be extended fully, when it could be flexed to the right angle and when the limb could be raised against gravity. A normal range of movement was restored within six months. *Mr John C Charney* (Manchester) emphasized the excellent functional results which could be secured by conservative treatment even in bilateral fractures of the femoral shafts. Bone plates were unphysiological. Intramedullary nailing had advantages in high shaft fractures. Fractures of the lower shaft of the femur were not suitable for nailing because of the trumpet shape of the bone but at this level conservative methods were ideal. *Mr K H Pridie* (Bristol) advocated Russell traction and pleaded that fractures of the femoral shaft should be protected from the hands of operating surgeons.

**Pedicled Nerve Graft with Discussion on Applicability of the Procedure**—*Mr F G St Clair Strange* (Canterbury) showed a result of pedicled nerve grafting after eighteen months. The operation had been planned for destruction of the median and ulnar nerves in the forearm over such an extent as to preclude direct suture. To bridge the median gap by means of a nerve graft with intact blood supply the lower ends of the proximal parts of median and ulnar nerves were sutured end-to-end, the ulnar nerve then being divided at a more proximal level without division of the accompanying vessels. At a second stage operation, the separated part of the ulnar nerve was swung down as a graft and its former proximal end was sutured to the distal strip of the median nerve the blood supply of the graft then coming across the first suture line. Although there was no motor recovery sensation of good quality returned to the whole median distribution. Seddon's postulate was thus fulfilled—the result of the nerve graft was at least as good as the results of direct nerve suture. *Dr J E Bateman* (Toronto) considered that the rigid tests which had been applied established this as a successful case of full-thickness nerve graft. *Dr Paul B Steele* (Pittsburgh) thought that bone shortening might have been considered as an alternative permitting direct suture of both nerves.

**Scoliosis with Paraplegia**—*Dr K G McKenzie and Dr F P Dewar* (Toronto) said that scoliosis with paraplegia was usually congenital, sometimes idiopathic and less often due to poliomyelitis rickets or Von Recklinghausen's neuro-fibromatosis. The deformity was severe. Myelograms sometimes showed a

block at the apex of the curve. If there was no early response to conservative treatment operation should not be delayed. The dura was found to be stretched tightly at the site of angular deformity, thus depressing the spinal cord which was not itself stretched; the pressure was released by division of the dura. *Dr. Arthur Stender* (Iowa) stated that paraplegia occurred in 0.3 per cent of all cases of scoliosis. Of five patients treated by operation, one died and the others were relieved or had steadily improved.

Other papers read at the meeting which are published in this number of the Journal or will be published in the next number together with the discussion include:

- Arthrodesis of the Hip Joint—Ichio Femoral Method—*Mr H. A. Brittain* (Norwich, England)
- Peroneal Spastic Flat Foot—*Dr Robert I. Harris* and *Dr F. Berth* (Toronto, Canada)
- Arthroplasty of the Knee Joint—Final Results—*Dr J. Edouard Samson* (Montreal, Canada)
- Intra-articular Arthroplasty of the Knee—*Dr J. S. Speed* and *Dr Philip C. Trout* (Memphis, Tennessee)
- Fracture Dislocation of the Pelvis—*Mr I. W. Holdsworth* (Sheffield, England)
- Developmental Coxarthrosis—*Dr A. B. Le Mesurier* (Toronto, Canada)
- Arthrodesis of the Ankle Joint—*Professor W. E. Gillie* (Toronto, Canada)
- Congenital Discoid Meniscus—*Mr I. S. Smillie* (Edinburgh, Scotland)
- Knee Joint Changes after Meniscectomy—*Mr T. J. I. Urbank* (London, England)
- Compression Arthrodesis of the Knee Joint—*Mr John C. Charnley* (Manchester, England)
- Denervation of the Elbow Joint for Relief of Pain—*Dr James E. Bateman* (Toronto, Canada)
- Elephantiasis with Congenital Bands in Children—*Dr A. W. Farmer* (Toronto, Canada)

### ROYAL COLLEGE OF SURGEONS OF ENGLAND

**Lord Webb-Johnson**—We offer our warmest congratulations to the President of the Royal College of Surgeons of England who in the birthday honours list in June 1948 was raised to the peerage. His title will be *Baron Webb-Johnson of Stoke-on-Trent*. His lordship was re-elected President of the College at the last quarterly meeting of Council; he thus has the unique distinction of holding this office with its onerous and responsible duties for no less than eight years, two years longer than *Lord Moynihan* who was president from 1923 to 1928.

**Lectures in the College**—A course of lectures on orthopaedic subjects was given at the College in Lincoln's Inn Fields in June and July 1948. Bone Growth—*Professor H. J. Seddon*, Strains and Sprains—*Mr H. Osmond-Clarke*, Fractures of the Pelvis—*Mr J. G. Bonnin*, Birth Fractures—*Mr Bryan McFarland*, Acute Haematogenous Osteomyelitis—*Mr R. Weeden Butler*, Fractures of the Forearm Bones—*Mr John Charnley*, Pott's Disease and Pott's Paraplegia—*Mr G. R. Girdlestone*, Non-tuberculous Affections of the Hip Joint in Childhood and Adolescence—*Mr K. I. Nissen*, Orthopaedic Appliances—*Mr Norman Capener*, Injuries of the Wrist and Carpus—*Mr Ronald Furlong*, Fractures of the Cervical Spine—*Mr A. N. Birkett*, Derangements of the Knee Joint—*Professor T. P. McMurray*.

Lectures on anatomy, applied physiology and pathology in July included: Bone Growth—*Professor H. A. Harris*, Inflammation and Repair—*Professor J. H. Dible*, Physiology of Nutrition—*Professor J. Beattie*, Collagen and Keratin—*Professor W. T. Astbury*, General Pathology of Bone—*Professor S. L. Baker*, The Autonomic Nervous System—*Professor D. T. Harris*, Repair of Connective Tissues—*Professor G. P. Wright*, The Source and Transmission of Wound Infection—*Professor R. Hare*.

A course of lectures in anaesthesia was held in June and July, and a course of lectures on general oral and dental surgery will be held in September. There will be a series of seventy-two lectures and practical demonstrations in anatomy, applied physiology and pathology from October 11, 1948, to January 14, 1949. There will be two lectures daily at 2.45 and 5 p.m., and the practical demonstrations will take place in the morning or early afternoon.

Lectures in surgery to be delivered in the College in the autumn will include:

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| October 4 | Traumatic Injuries of the Abdomen— <i>Mr Guy Blackburn</i>                          |
| 1948 5    | Treatment of Burns— <i>Mr A. B. Wallace</i>   |
| 6         | The Interpretation of Visceral Pain— <i>Professor F. H. Bentley</i>                 |
| 8         | Bone Graft Surgery— <i>Mr H. Jackson Burrows</i>                                    |
| 11        | Rehabilitation and Surgery— <i>Mr F. S. Cooksey</i>                                 |
| 12        | Surgery of the Heart and Great Vessels— <i>Mr R. C. Brock</i>                       |
| 13        | Pathological Physiology of Arterial Disease— <i>Professor J. R. Learmonth</i>       |
| 14        | Congenital Deformities of the Extremities— <i>Mr Denis Browne</i>                   |
| 15        | Surgery of Pulmonary Tuberculosis— <i>Mr T. Holmes Sellers</i>                      |
| 18        | High Voltage X-rays in the Treatment of Malignant Tumours— <i>Dr D. W. Smithers</i> |
| 20        | Surgery of the Sympathetic Nervous System— <i>Professor J. Paterson Ross</i>        |
| 21        | Surgery of Sepsis— <i>Mr P. H. Mitchiner</i>  |

## ORTHOPAEDIC SECTION OF THE ROYAL SOCIETY OF MEDICINE

The summer meeting of the Orthopaedic Section of the Royal Society of Medicine was held at the Essex County Hospital Black Notley, on July 10, 1948. The morning was devoted to clinical and technical demonstrations. Cases which were shown included arthroplasty of the hip and osteotomy of the spine, by Mr Alexander Law; combined skeletal and renal tuberculosis by Mr R. W. Reid; combined skeletal and pulmonary tuberculosis by Dr R. C. Cohen; and torticollis by Mr Whitchurch Howell. The treatment of tuberculosis of the hip and of the spine was shown by Dr M. C. Wilkinson and Mr D. Dunn. A demonstration of tomographic apparatus by Dr Franklyn Wood showed convincingly that tomography is of great value in radiographic studies of the spine, sternum, sterno-clavicular joints, and hip joints. Models illustrating the pathology and radiographic examination of recurrent dislocation of the shoulder were demonstrated by Mr J. C. Adams.

**Bacterium-free filtrate of tuberculous pus**—Dr M. C. Wilkinson described the therapeutic use of a bacterium-free filtrate of tuberculous pus which is under trial at Black Notley Hospital in the treatment of skeletal tuberculosis. His suggestion was that the filtrate results in desensitisation of the patient and the elimination of allergic reactions. While emphasizing that his clinical researches lacked scientific confirmation, his impression was that beneficial results occurred in a sufficient number of instances to justify further trial.

**Surgical fusion of the tuberculous spine in children**—Mr Denis Dunn discussed the results of treatment of spinal tuberculosis in children with special reference to the use of spinal fusion. The conclusion he had reached from a study of eighty-nine cases was that fusion as performed in these cases was of no value either from the point of view of reducing the mortality, ensuring freedom from recurrence of the disease, or preventing deformity. Much interest was shown in this problem during the subsequent discussion. Mr Cholmonley stated that in general he was opposed to grafting in the treatment of spinal tuberculosis in children. In his opinion the graft, if mechanically successful, was liable to prevent approximation of the partly destroyed vertebral bodies and thus to delay healing. In his opinion the breaking of such a graft was a fortunate occurrence. Mr J. C. Scott was in general agreement but suggested that spinal fusion was useful in the adult at a stage when the disease was completely quiescent. Mr G. Perkins, in putting forward the view widely held in America that grafting should be performed early in the course of treatment with a view to providing rigid immobilisation, emphasized that one of the major advantages of this method lay in the possibility of preventing gross deformity.

**Orthopaedic Nursing**—Miss M. Ruck, Matron at Black Notley Hospital, gave a balanced account of the problems of the orthopaedic ward as seen from the nurses' point of view. She emphasized the need for the selection of the most suitable type of girl for the nursing of long-stay orthopaedic cases where the maintenance of good morale was of prime importance. She deprecated the recent proposal to curtail specialist nursing training. The structural details of an orthopaedic ward which she regarded as most important were: capacity of approximately twenty-five beds with generous spacing; beds to be grouped in cubical units of four or five beds in single row facing a verandah; a number of single rooms for seriously ill patients and for post-operative cases; adequate annexes; and a clinical room for the examination of ambulant patients under optimum conditions.

## THE INSTITUTE OF ORTHOPAEDICS

### BRITISH POST-GRADUATE MEDICAL FEDERATION OF THE UNIVERSITY OF LONDON

In recent years the University of London has set up a Post-graduate Medical Federation under the direction of Sir Francis Fraser to co-ordinate the work of the Post-graduate Medical School with that of a series of new institutes in the specialties of neurology, ophthalmology, diseases of the chest, pediatrics, orthopaedics, etc., these institutes being based on the world-famous hospitals of Queens Square, Moorfield, Brompton, and Great Ormond Street. The Institute of Orthopaedics was established at the Royal National Orthopaedic Hospital which carries the great traditions of Little Tubby, Elmslie, Bankart, Fairbank and other pioneers. This hospital, with its centrally situated town section in proximity to the principal University Departments and the Royal College of Surgeons, has also a modern country section ten miles away. The two sections between them provide 500 beds. In order to meet the academic requirements of post-graduate study, school and laboratory accommodation is being built at both town and country branches, and a number of new academic and clinical posts have been established.

**Appointment of Mr H. J. Seddon as Director of Studies**—A selection committee representing the University of London, the Institute of Orthopaedics, the Royal National Orthopaedic Hospital, and the Royal College of Surgeons of England, considered carefully the appointment of Director of Studies. Discussions were held with a number of leading orthopaedic surgeons in this country and the Dominions and finally Mr H. J. Seddon, until recently Nuffield Professor at the University of Oxford, was invited to become the first Director of Studies of the Institute and Clinical Director of the Hospital. Mr Seddon, who is forty-four years of age, was trained at St Bartholomew's Hospital, and when he graduated as

Bachelor of Medicine in 1925 he was awarded the gold medal. In the same year he became a Fellow of the Royal College of Surgeons. In 1930 he was appointed to an instructorship in surgery at Ann Arbor Michigan under Professor Hugh Cabot and Dr Vernon Hurt. On return to London he served as chief assistant in the Orthopaedic Department of St Bartholomew's and shortly afterwards was appointed resident surgeon at the Stanmore Branch of the Royal National Orthopaedic Hospital. In 1933 he won the Robert Jones gold medal of the British Orthopaedic Association for his study on Pott's paraplegia and in 1935 lectured on Caries of the Thoracic Spine as Hunterian Professor in the Royal College of Surgeons of England. In 1940 he was appointed to the Nuffield Chair of Orthopaedic Surgery in the University of Oxford and was awarded the degree of D.M. In 1943 and 1945 he was invited by the Colonial Secretary to visit Malta and Mauritius to advise on the outbreaks of polyomyelitis. Mr Seddon has already begun his new duties in London and we look forward to the increasingly important share which the Institute of Orthopaedics will take in post graduate education in collaboration with other London hospitals and with the Royal College of Surgeons of England.



Mr H. J. Seddon recently appointed Director of Studies at the Institute of Orthopaedics University of London

### SCIENTIFIC AND ORTHOPAEDIC CONFERENCES

**World Congress on Physical Education**—The International Congress on Physical Education Recreation and Rehabilitation arranged in association with the Olympic Games was held in London from July 23 to 26. Representatives attended from seventy one countries including the Dominions and Colonies. The Congress was opened by the Minister of Education. Some indication was given of physical education in Britain in schools and colleges physical recreation in after-school life and rehabilitation after industrial injuries. An address on rehabilitation was given by Sir Reginald Watson-Jones. A film on rehabilitation in the Royal Air Force was shown by Group-Captain Cook and Squadron-Leader L. F. Mason and there was a demonstration on resettlement of the disabled in industry arranged by Messrs Vauxhall Motors Ltd of Luton. The closing address was delivered by Professor Arthur Newell.

**First International Students' Clinical Congress**—The first International Congress of Clinical Medicine arranged by the British Medical Students Association was held in July in London, Birmingham and Oxford under the presidency of Professor J. A. Ryle of Oxford. Over 200 delegates from more than thirty countries attended clinical rounds in hospitals, lectures, the showing of medical films and visits to research laboratories.

**Second International Scientific Conference at Aix les Bains**—At the International Scientific Conference held in June the problems of chronic degenerative arthritis were discussed by thirty-three contributors under the presidency of Professor Leriche of Paris.

**Journee Orthopédique Parisienne and XXIIIe Réunion de la Société Française d'Orthopédie et de Traumatologie**—The Journee Orthopedique Parisienne will be held on Friday October 1, 1948 immediately before the twenty-third annual meeting of the French Society of Orthopaedic and Traumatic Surgery under the presidency of Professor Jacques Leveuf. On Friday there will be operative and clinical sessions and on Saturday discussions on the correction of inequality in the length of the lower limbs opened by M. Bertrand of Paris and M. Trillat of Lyons and on the treatment of fractures of both bones of the forearm opened by M. Fèvre of Paris and M. Robert Soeur of Brussels.

**Congress of the Czechoslovak Society for Orthopaedic Surgery and Traumatology**—The annual meeting of the Czechoslovak Society for Orthopaedic Surgery and Traumatology will be held in Prague under the presidency of Professor J. Zahradnický on September 23 to 26, 1948 when there will be discussions on the treatment of congenital dislocation of the hip joint and on diseases of the locomotor system in their relationship to public health.

**Dame Agnes Hunt**—Dame Agnes Gwendoline Hunt D.B.E. R.R.C. founder of the orthopaedic hospital in Shropshire now known the world over as the Robert Jones and Agnes Hunt Orthopaedic Hospital and of the Derwen Cripples Training College died at her home in Baschurch Shropshire on Saturday July 24 at the age of eighty-one years. An appreciation of her life and a commentary on the epoch of orthopaedic surgery which with her passing is now closed will be included in the next number of the Journal.

# Book Reviews

BRITISH JOURNAL OF PLASTIC SURGERY Edited by A. B. WALLACE MSc FRCS (Edin)  
Appearing quarterly Volume I No 1  $9\frac{1}{2} \times 6\frac{1}{2}$  in Pp viii+72, with many figures 1948 Edinburgh  
E & S Livingstone Ltd Price 12/6 single issue or £2 2/- annual subscription

Plastic surgery was born in the first World War and it reached true maturity in the second. It has thoroughly justified itself. This war has not only produced great advances in both plastic surgery and orthopaedics but it has linked them closely and fruitfully. Each has been stimulated and improved by the other to their common great advantage and advancement. Consequently the inception of the British Journal of Plastic Surgery may be considered a major event in orthopaedics as well as a welcome symbol of the advance of plastic surgery. The distinguished editor and board and the contributors and the publishers are to be congratulated on an excellent first number. Some of the articles have no special interest for orthopaedic surgeons but there are very good contributions on lymphoedema by Rainsford Mowlem pollicisation of the index finger by James B. Cuthbert and F. T. Moore and construction of the web in syndactyly by Michael C. Oldfield.—H. JACKSON BURROWS



FIG 5

(Page 58)



FIG 6

Final condition (after pollicisation of index finger)

PATHOLOGY OF TUMOURS By R. A. WILLIS DSc MD, FRCP, Sir William H. COLLINS  
Professor of Human and Comparative Pathology Royal College of Surgeons London  $9\frac{1}{2} \times 7$  in Pp  
xxiii+992 with 500 figures Index 1948 London Butterworth & Co., Ltd Price 63/-, plus 1/6  
postage

The issue of this new book is opportune and notable. For many years the chief work of reference on this subject has been Ewing's "Neoplastic Diseases". But Ewing is now dead and the last edition of his book was published in 1940. Though the latter will continue to be used, this newer work will probably be consulted more frequently alongside the microscope because it is designed particularly to give diagnostic help with the more subtle tumours. The author has imparted to it his own individual outlook illustrating it throughout from his own extensive experience. Those already familiar with his earlier work "The Spread of Tumours in the Human Body" (1934) will recall his wide grasp of the literature, the fine balance of his judgment, and commonsense attitude towards various controversial matters. They will know what to expect in this larger work and they will not be disappointed. To some he will appear over dogmatic in his interpretation of such arguable topics as Ewing's tumour of the bones and his refusal to entertain the existence of the primary endotheliomata of serous membranes. But his dogmatism is always

founded upon reason and in such matters his treatment has the merit of being provocative and it affords more interesting reading than an inconclusive statement of pros and cons

The first part of the book gives a general account of tumours and their habits along similar lines to that of Living, the remainder is devoted to the features of tumours in special sites. The whole is lavishly and excellently illustrated again with an eye to the portrayal of the more problematical tumours. The text is amplified with brief notes of cases seen by the author and a novel and acceptable feature is the addition of short sections in each chapter on the occurrence of analogous tumours in the lower animals.

A bibliography ends each chapter and here too the author helps by indicating the articles that he considers most useful. For a work of this size the text and references are astonishingly up-to-date a tribute both to the author and in these difficult days the publisher. Altogether this may be judged a same eminently readable and informative work which will prove of immense value both in the laboratory and library.—Dorothy S. RUSSELL

**HANDBOOK ON FRACTURES** By Duncan EVE Jun MD FACS 9×6½ in Pp xi+263 with 129 figures Index 1947 London Henry Kimpton Price 25/-

This well written book enunciates clearly and soundly the modern principles of treatment of fractures. It does not include dislocations. It is intended mainly for senior students and junior house staff and not for surgeons who specialise in accident work. Fig 6 conveys the impression that crutches are usual when walking in a plaster cast. The use of penicillin in the management of early secondary suture of compound fractures is not mentioned but the general principles of their treatment are discussed soundly. Often the descriptions are insufficiently precise for instance that dealing with the treatment of a Bennett's fracture would not enable the reader to treat the majority of such fractures successfully. Many of the reproductions of radiographs are so dark that details are obscured.—L. W. PLEWES



FIG 48 Page 32

A case of Charcot's knee. Spontaneous dislocation has occurred. There is also a large perforating ulcer of the foot which is covered by the dressing.

**DEMONSTRATIONS OF PHYSICAL SIGNS IN CLINICAL SURGERY** By Hamilton BAILLY FRCS FACS FICS FRSE Surgeon Royal Northern Hospital London Eleventh edition In four parts Part I 8½×5½ in Pp vii+100 with 178 figures many in colour 1948 Bristol John Wright & Sons Ltd Price 8/6 each part Paper cover

This book written by one of the greatest of our surgical teachers must be a best seller. It has reached an eleventh edition it has appeared in German Turkish Spanish and Bulgarian and it is about to appear in other languages. The author liberally acknowledges help from both sides of the Atlantic. Impatient of present difficulties and delays he is producing this edition in four parts of which the first has now appeared. Such an expedient is not entirely satisfactory for instance this part contains a chapter on Some general principles in the examination of joints but we must await a future part for the detailed examination of individual joints. We deplore with the author that medical students text-books (and indeed most educational scientific and medical works) have in the main to take their turn in delivery of paper from the mills printing and binding with manuals on greyhound racing and How to Play Poker. Another difficulty has been the production of colour blocks. Though many are first class others are out of register but on the whole the illustrations are excellent and are commendably numerous. The text is clear concise and easy.—H. Jackson BURROWS



THE ESSENTIALS OF MODERN SURGERY Edited by R M HANDFIELD-JONES, M C, M S F R C S Surgeon to His Majesty the King, Surgeon St Mary's Hospital, London, and A E PORRITT, C B E M A M Ch F R C S Surgeon, St Mary's Hospital, and Lecturer in Surgery, St Mary's Hospital Medical School London Third edition  $9\frac{1}{2} \times 6\frac{1}{2}$  in Pp xiv+1256, with 644 figures, many in colour Index 1948 Edinburgh F & S Livingstone, Ltd Price 50/-

This third edition which succeeds in the main in its purpose of "providing students and practitioners with the essentials of modern surgery in as concise a form as possible" The authors have enlisted the co-operation of twelve other contributors, among whom are Brockman, Mercer, and Paton, so that it cannot be said that the sections on orthopaedic surgery have been written by men who are unfamiliar with their subject An unusual approach might have been expected But the book is respectable and orthodox and it differs little from other text-books on Surgery How one longs for a book written by a surgeon who had never read a text-book! It goes without saying, since it is produced by Livingstone's that it is aesthetically satisfying—George PERKINS

THE SCIENCE AND PRACTICE OF SURGERY By W H C ROMANIS M A, M B M Ch (Cantab) F R C S (Eng) F R S (E) Senior Surgeon and Lecturer in Surgery, St Thomas's Hospital London and Philip H MITCHNER C B C B E, T D M D M S (Lond) F R C S (Eng) D Ch (Durham) Hon Surgeon to His Majesty the King Surgeon and Lecturer in Surgery St Thomas's Hospital, London Eighth edition  $9\frac{1}{2} \times 7$  in Volume I General Surgery Pp vi+892 with 408 figures and 20 plates Index Volume II Regional Surgery Pp vii+955, with 316 figures and 8 plates Index 1948 London J & A Churchill Ltd Price 25/- each volume

The eighth edition of this well-known text coincides with its coming of age We can well remember twenty-one years ago the joy with which a certain resident surgical officer showed us the first edition with the remark that here at least and at last was a satisfying book on surgery He was obviously right for a book which goes to eight editions needs no boosting and may almost justify some boasting It is good that both the authors who launched it have been able to revise this edition A surgical text book soon gets out of date and since the last edition there have been momentous discoveries such as that of penicillin which must have made the task of revision somewhat arduous However it appears to have been done well

The book is comprehensive, as may be judged by the fact that there are 1,776 pages of reading matter 463 of which deal with subjects which concern the orthopaedic surgeon Within this space there has been included a clear and didactic account of diseases and injuries affecting bones joints and nerves The authors have been timid in qualifying their recommendation of the insertion of the Smith-Petersen nail for fractured neck of the femur In the account of hallux valgus they do not mention the operation of removal of the base of the proximal phalanx In the paragraph on the treatment of causalgia periarterial sympathectomy is mentioned, but no reference is made to cervical sympathectomy These are but minor lacunae and they do not detract from the opinion that this book is a credit to authors and publishers alike Just one misprint we found—Gibson for Sibson—Zachary COPE

# The Journal of Bone and Joint Surgery

## THE JOY OF LIFE

This number of the Journal is dedicated to Agnes Hunt, the "Florence Nightingale of orthopaedic nursing," whose recent death, at the age of eighty-one, marks the conclusion of an era of British surgery characterised by the work of three great leaders—a pioneer of somewhat forbidding austerity—Hugh Owen Thomas, a humanitarian of cheerful benignity—Robert Jones, and a crippled nurse of good humoured determination—Agnes Hunt. It has often been said that Robert Jones' greatest contribution to surgery was that he made acceptable the teachings of Hugh Owen Thomas whose austere and sometimes harsh criticism made enemies where he should have made friends, and who could not himself gain general acceptance of the surgical principles in which both he and his nephew believed. Why did Robert Jones succeed where Thomas had failed? Why was it possible for Agnes Hunt to build a great orthopaedic hospital, create a system of after-care clinics, and establish a new principle of training and resettlement of the disabled? What was it that Robert Jones shared so closely with Agnes Hunt whose personality was in many respects similar to his own? It might have been that diplomacy and tact were coupled with supreme integrity of purpose, or that Robert Jones spoke ill of no man so that all knew they could trust him absolutely. It might have been that both he and Agnes Hunt recognised merit not only in their equals but in their juniors, and having once recognised it gave encouragement, with complete disregard for personal feelings of jealousy. These qualities they shared, but there was more. All who knew Robert Jones will remember the twinkle in his eye, all who knew Agnes Hunt will remember the twinkle in her eye, each had a keen sense of humour, a puckish wit, and an almost child-like pleasure in the simple fun of playing pranks. Incidents in the life of Robert Jones which he delighted to recount in those too short intervals between dinner and the early hour of his retirement reflected the irrepressibility of a boyish sense of fun which he indulged, no matter whether in the consulting room, the council chamber, or the Royal palace, where others might have hesitated lest their behaviour had been considered undignified. Neither Robert Jones nor Agnes Hunt believed that dignity was to be sought by rigid discipline of behaviour, yet each achieved supreme dignity. They believed in the joy of life and they believed in showing it, and it is certain that without these qualities their brilliant success in the treatment of a patient, the organisation of a hospital, or the establishment of a great reform, could never have been achieved. Let us therefore not be ashamed of occasional frivolity, a sense of humour, and simple child-like pleasure, and neither let us be ashamed of showing it in our behaviour, our speech, and even in our writing.

## ROBERT JONES AND AGNES HUNT ORTHOPAEDIC HOSPITAL

An appreciation of the life of Dame Agnes Hunt which is published in this number of the Journal makes reference to the Shropshire Orthopaedic Hospital, the title of which was changed to the Robert Jones and Agnes Hunt Orthopaedic Hospital in order to perpetuate the memory and ideals of its first surgical director and its founder. This hospital has a traditional background of its own. More than that, it differs in one fundamental respect from other important orthopaedic hospitals. The difference lies not in the fact that selected patients may still be drawn from distant areas—the Midlands, Westmorland, Cumberland,

Yorkshire, every county in Wales, and the Home Counties in the South, but that from its very inception until this day members of the staff of surgical consultants have travelled from distant University centres and cities—Liverpool, Birmingham, Cardiff, Shrewsbury, Chester, Manchester, and London, and that, as might be expected from a visiting staff of such national distribution, the resident surgical staff has been of international distribution including a high proportion of young surgeons from Australia, South Africa, Canada, and the United States of America. It is easy to suggest that with so widely distributed a staff the hospital is less neat and tidy in its plan than is the usual regional hospital, under a single director, attended only by surgeons who live in close proximity. But in a day when central planning may lead to increasing uniformity it is wise to preserve the individuality which is known to have been the wish of its founder and of its first and greatest surgical director. Long may this hospital continue to be served by distinguished orthopaedic surgeons from all the great cities of the country. The inspiration of a hospital service which is stimulated from many sources is not to be measured in terms of a tidy plan, and though dissemination of the influences brought to bear upon it may perhaps involve some loss, there can be no possible doubt that it confers greater gain. The Robert Jones and Agnes Hunt Hospital stands far above the boundaries of any region, it is a national and indeed an international hospital.

### POST-GRADUATE ORTHOPAEDIC TRAINING

One other orthopaedic hospital in this country, also with a long history and with special traditions of its own, has turned to the problem of post-graduate training and the reception of surgeons from overseas—the Royal National Orthopaedic Hospital, London, with its Institute of Orthopaedics which is part of the British Post-graduate Medical Federation of the University of London. This hospital, and the Robert Jones and Agnes Hunt Orthopaedic Hospital, with the post-graduate orthopaedic centre of the University of Liverpool, and all the important orthopaedic centres of the country, supported by the British Orthopaedic Association, is planning co-ordination in the training of orthopaedic surgeons from Britain, the Dominions, and other countries overseas. A first meeting was held a few weeks ago in the Royal College of Surgeons of England which has conferred its blessing and granted the weight of its authority and tradition. It is hoped that by such co-ordination the training of young orthopaedic surgeons will be enhanced in so far as the stimulus of more than one orthopaedic centre will be gained, and that surgeons from overseas will be given the opportunity of experiencing a broad cross-section of the orthopaedic practice of the country.

### INTERNATIONAL MEETINGS

The fourth congress of the International Society of Orthopaedic and Traumatic Surgery was held recently in Amsterdam. As a social occasion the meeting was so great a success as to warrant the belief that such gatherings are justified if for no other reason than that the surgeons of many countries may meet and learn to know each other. As an international scientific congress the success of the meeting was perhaps open to doubt. On one day there were forty-two papers, each with a ten-minute limit. One correspondent writes "Many speakers had much more than twenty minutes' material to present within the ten-minute limit and they were determined to beat the red light. They spoke at three times the normal rate and few of us understood a word." If these meetings are to be regarded as no more than social occasions we must apply ourselves to the language problem, which has been solved at international political conferences and can surely be solved at international scientific meetings. Incidentally, if the International Society of Orthopaedic and Traumatic Surgery is to command the respect and allegiance of democratic countries it must publish its constitution so that we may know how representatives and delegates are appointed.

EDITOR

# ISCHAEMIC NECROSIS OF THE ANTERIOR TIBIAL MUSCLES DUE TO FATIGUE

J ROWLAND HUGHES, LIVERPOOL, ENGLAND

*From the Liverpool Open Air Hospital for Children, Leasowe  
Formerly of the Orthopaedic Service the Royal Air Force*

Ischaemic necrosis of the lower limb muscles is well recognised as a complication of injury and recorded cases show that, as in the upper extremity, isolated muscles or muscle groups may be affected (Bruce 1940, Parkes 1945, Wood Power 1945). Traumatic ischaemic necrosis of the anterior tibial group of muscles may thus occur, but it is less widely appreciated that such necrosis may also arise when there has been no injury at all.

Hill and Brooks (1936) described muscle contractures arising spontaneously in patients suffering from haemophilia, but it is uncertain whether any of these were due to ischaemic muscle necrosis. Horn (1945) recorded two cases of contracture of the tibialis anterior and the long extensors of the toes in young healthy soldiers after strenuous exercise, and he quoted Vogt as having recognised the syndrome in soldiers after marching. This relationship between exercise and circulatory disturbances of the anterior tibial muscles was stressed by Sirbu, Murphy, and White (1944), who described the case of a young soldier in whom ischaemia of the anterior tibial group of muscles was believed to have been attributable directly to route-marching. Mr J. C. Scott of Oxford tells me that he has knowledge of four such cases, occurring in healthy young adults after strenuous and unaccustomed activity. There can be little doubt, however, that many cases have passed unrecognised, particularly in the acute phase, and this is borne out by the cases now reported.

## CASE REPORTS

**Case 1** *Sergeant C* *History*—On September 13 1945 after playing football he felt that his right knee was somewhat stiff. During the game he had experienced no cramp or pain in the leg and suffered no injury. He had not played football for several months before this game but his health had been perfect and there had been no previous symptoms. The next day he complained of pain in the whole of the right lower leg and he was reluctant to move the ankle joint. A surgeon diagnosed acute tenosynovitis of the tibialis anterior and applied a viscopaste bandage. The next day the patient reported sick, the pain was unabated and he was admitted to hospital.

*Clinical examination*—The patient was a healthy young adult twenty-three years of age and he showed these clinical features: 1) swelling of moderate degree over the antero-lateral aspect of the right lower leg as far as the ankle; 2) tense glossy redness of the skin over the middle third of the anterior tibial compartment; 3) extreme tenderness and induration of the whole of the anterior tibial compartment with a little tenderness over the tibialis anterior at the ankle joint; 4) absolute reluctance to perform any active movement of the ankle joint due presumably to pain. There was no pallor or cyanosis of the toes, no sensory loss and no evidence of cardio-vascular or other systemic disease. The temperature was 99.2° F, the blood sedimentation rate was 28 mm in the first hour (Westergren), the total white cell count was 11 600 per cu. mm.

A diagnosis of cellulitis was made and the limb was immobilised in a Thomas bed knee splint. The pain and discomfort settled gradually and by September 29 the tenderness, swelling and redness had disappeared but there was still slight evening pyrexia, the blood sedimentation rate was 14 mm in the first hour. At no time did radiographic examination show evidence of bone injury or disease. Examination on October 4 showed that the muscle belly of the tibialis anterior was abnormally hard, from a level two inches below the tibial tubercle to the junction of the middle and lower two-thirds of the leg. The other muscles of the anterior tibial group were not quite so hard. Active extension of the ankle joint was limited just below the right angle and it was weak. Plantar-flexion was restricted by contracture of the tibialis anterior and to a lesser extent by contracture of the long extensors of the toes. The peroneal muscles were acting normally. There were no vascular or sensory changes in the foot.

*Biopsy*—October 11 twenty-eight days after the onset of symptoms. The deep fascia of the anterior tibial compartment and the muscle sheaths were fused into one thick sheet. Incision revealed that the muscle was pale pink-grey in colour, hard and without contractile response to mechanical stimulation.

There was little response to direct galvanic stimulation, and no response to strong faradism. It was noted that there was venous oozing from the affected group of muscles. Part of the tibialis anterior muscle was taken for section, and also for purposes of comparison, a small piece of the gastrocnemius muscle which showed a healthy brick-red colour and was briskly contractile. *Histological examination* of the affected muscle showed gross changes typical of ischaemic necrosis (Fig 1).

*Progress*—The patient was fitted with a toe-elevating spring which he wore for five weeks. Follow up examination in March 1946 showed persistent hardness of muscles in the middle third of the anterior tibial compartment. The total range of active movement of the ankle was 15 degrees. Contracture was maximal in the tibialis anterior and was present to a much less degree in the extensor hallucis longus and the extensor digitorum longus. There were no sensory changes. The patient walked well. His only complaint was of occasional aching in the limb.

**Case 2 Leading-Aircraftman S**—A young adult twenty years of age had complained of vague pain over the antero-lateral aspect of both lower limbs for nine months. After playing football on May 22 1946 he noticed dull aching in front of his right lower leg, the whole leg and ankle joint felt stiff. At no time during the game did he experience pain or cramp, nor did he sustain injury. It was not until several hours after the game that symptoms arose. The next day the leg was swollen and very painful and he was admitted to hospital where he received a course of penicillin injections and sulphapyridine followed later by faradism, radiant heat, and massage. No further details of the clinical condition are available but the treatment which was given suggests that the clinical picture resembled that of an acute inflammatory lesion. After two months he was transferred to another hospital.

*Clinical examination*—There was 1) one inch wasting of the right calf 2) a palpable woody hard area corresponding to the lower two thirds of the tibialis anterior, 3) limitation of active and passive plantar flexion at the ankle joint due to contracture of the anterior tibial group of muscles 4) marked weakness of active dorsiflexion of the ankle joint 5) no more than a suspicion of active contraction of the tibialis anterior muscle and a flicker of contraction in the extensor hallucis longus but good contraction of the extensor digitorum longus and vigorous action in the peronei 6) diminished sensation over the dorsum of the foot and front of ankle. There was no evidence of vascular impairment in the foot, no swelling, no erythema, no tenderness over the anterior tibial compartment, and no evidence of cardio-vascular or other systemic disease. Radiographic examination of the limb showed no abnormality. The blood sedimentation rate was 2 mm in the first hour (Westergren). The Wassermann reaction was negative. Electrical reactions showed negligible response to faradism and a weak response to galvanism in all anterior tibial muscles.

*Biopsy*—September 19, four months after the onset of symptoms, showed that the muscle fibres were yellow white in colour and very resistant to cutting with a knife. The muscle had undergone mass necrosis and was surrounded by dense cellular fibrous tissue. The summary of the histological report was in the words 'the picture is that of ischaemic necrosis' (Fig 2).

**Case 3 Leading-Aircraftman H**, aged nineteen years was admitted to the medical wards of a regional hospital on December 15 1945 with swelling of the neck and face, dysphagia, and weakness of the legs. He gave a history of similar previous attacks which on the last occasion had been diagnosed as acute thyroiditis. There was no history of injury or of cramp in the legs. While under investigation he developed crops of subcutaneous nodules, blue in colour, varying from  $\frac{1}{4}$  inch to  $1\frac{1}{2}$  inches in diameter, situated over the chin, thigh, scrotum, forearms and lower limbs. Each crop of nodules was associated with pyrexia, but blood cultures were negative. *Investigations* showed blood count—red blood corpuscles 4.5 million per cu mm, haemoglobin, 70 per cent, white blood count, 9200 per cu mm, differential count no significant change, blood sedimentation rate, 36 mm in the first hour (Westergren), Wassermann reaction negative, prothrombin time, normal, other investigations, negative. *Biopsy of subcutaneous nodule*—The summary of Professor G. R. Cameron's report on histological examination of one of the nodules is: "Some of the lesions are very similar to the acute stage of periarteritis nodosa but there is not much doubt that a rheumatic infection is the most likely cause of the condition." On February 28 1946, the patient complained of pain in both feet. The ankles and feet were swollen and there was a large nodule on the right sole. A further crop of nodules appeared, mainly in the limbs, associated with pyrexia of 101° F. After a course of salicylates, the symptoms subsided. When he was transferred to an orthopaedic centre he had been getting up for most of the day but he complained of weakness of the lower limbs.

*Clinical examination*—1) Active and passive plantar-flexion at both ankle joints were limited to 15 degrees by bilateral contractures of the tibialis anterior and extensor hallucis longus 2) active dorsiflexion was very weak on both sides and was accomplished mainly by the extensor digitorum longus, 3) there was woody hardness over the anterior tibial compartments in both legs 4) the anterior tibial pulse was not palpable at the ankle joint 5) there was no sensory disturbance in either leg.

*Biopsy of muscles*—May 30 1946 Both anterior tibial groups of muscles were explored The fascia was thickened and fused with the sheaths of the underlying muscles the latter being pale, hard and fibrous and not reacting to stimulation with the knife There was faint response to direct faradic and galvanic stimulation On both sides the tibialis anterior and to a lesser extent the extensor hallucis longus, were affected, the extensor digitorum communis was involved mildly Attempted exposure of the anterior tibial artery was made difficult by extensive fibrosis within the compartment Specimens of the affected muscle and of the normal gastrocnemius were taken for section *Histological examination* showed changes in the anterior tibial muscles similar to those of Volkmann's ischaemic contracture (Fig 3) *Progress*—Plaster back slabs were applied at night and toe elevating springs were used for walking When last seen the patient was able to get about fairly well

*Comment*—The exact nature of the systemic disease in this case is a matter of conjecture Infarction of the anterior tibial muscles was not recognised so that the precise time of onset, in relation to the general disturbance, remains uncertain It is possible that this occurred on February 28, 1946, when it was recorded that an attack of pyrexia was associated with pain and swelling of both ankles However, further questioning, after transfer to an orthopaedic centre, revealed that from the time of onset of the illness the patient had experienced pain in both legs, particularly on the antero-lateral aspect where there was some swelling and redness That these muscles should be picked out in this way, while the patient was confined to bed, illustrates their peculiar vulnerability to ischaemia even in the absence of physical exercise

#### CLINICAL FEATURES

In the acute phase of the condition the clinical picture is sufficiently characteristic to permit accurate diagnosis It is only failure to bear in mind the possibility of this lesion which accounts for the fact that so many cases pass unrecognised During the first three or four hours the clinical features resemble those of tenosynovitis of the tibialis anterior, but there is no typical crepitation

From twelve to twenty-four hours after the onset there is evidence of intense local reactionary inflammation (Lewis 1936) The skin over the anterior tibial compartment, particularly in its lower two-thirds, is tense, glossy, erythematous, and indurated Swelling may extend as far as the ankle joint There is often low pyrexia The blood sedimentation rate shows a marked rise and there may be leucocytosis It is not surprising, therefore, that most recorded cases were first diagnosed as cellulitis of the leg Horn (1945) described the onset of pain as sudden and severe, and occurring during exercise This was not the typical history in the cases here recorded These patients described a sensation of stiffness over the outer aspect of the shin, and later of aching, gradually mounting to severe pain which reached its greatest intensity from twelve to twenty-four hours later

Peroneal palsy has been described, but it was not a conspicuous feature in these cases In Case 1 there was complete loss of voluntary movement at the ankle joint during the acutely painful phase but there was no sensory change In Case 2 there was a small area of residual hypoalgesia over the dorsum of the foot The peroneal muscles were not involved In this respect it is interesting to note that Case 3 was referred to the orthopaedic department because it was thought he had bilateral "drop foot", in the sense that there was marked weakness of dorsiflexion this was true, but there was no evidence of a peroneal nerve lesion

In established cases, when inflammatory reaction has been succeeded by replacement fibrosis, the predominant symptom may be "weakness in the legs" There is obvious weakness of active dorsiflexion of the ankle joint, and often of the great toe Active and passive plantar-flexion at the joint is limited by contracture of the tibialis anterior, and to a lesser degree by contracture of the long extensors of the toes Palpation of the limb shows typical rigid firmness over the anterior fascial compartment, particularly in its middle third The anterior tibial pulse may be diminished or absent—a sign which is of doubtful value

DISCUSSION

**Morbid histology**—Obstructive vascular lesions in muscle may be of two main types—venous and arterial. In each type the histological picture is characteristic (Brooks 1922, Middleton 1930, Griffiths 1940, Bowden and Guttman 1945).

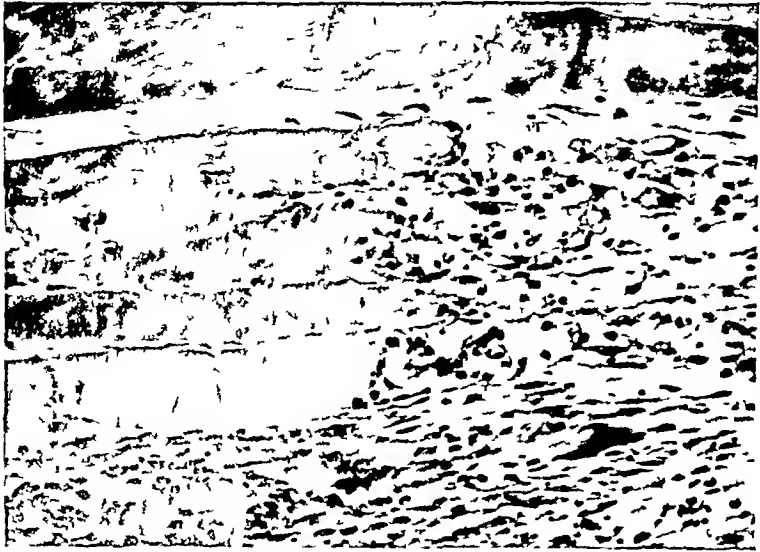


FIG 1

Case 1 Microphotograph showing peripheral zone of necrotic anterior tibial muscle ( $\times 140$ )

Case 2 (Fig 2) areas of muscle have undergone mass necrosis, while still retaining their structural outlines the fibres exhibit no nuclear staining, closely investing the necrotic muscle is a zone of dense fibrous tissue in which remnants of degenerated muscle fibres persist.

Professor Le Gros Clark (1946) produced identical lesions in the lower two-thirds of the tibialis anterior muscle of rabbits by ligating the main vessels, and demonstrated the remarkable degree of regeneration of muscle fibres which might occur within three weeks, provided that a stump of healthy muscle fibre remained. He showed convincingly that fine strands of protoplasm streamed down the muscle tubes into the necrotic area until, by the end of four months, the whole of the necrotic area was completely replaced by newly regenerated muscle fibres.

**Regeneration of necrotic muscle in the human being**

Figs 5 and 7 show unmistakably that such regeneration can occur also in human muscle. When asked for his opinion on these sections, Le Gros Clark pointed out that the difficulty in regeneration of human muscle, as compared with the muscle of rabbits, arose from its bulk, after ischaemic necrosis



FIG 2

Case 2 Muscle sequestrum surrounded by mature fibrous tissue appearance four months after onset ( $\times 100$ )

extensive fibrosis occurred before the regenerating fibres had time to cover the ground. Sprouting fibres soon met with the obstruction of fibrous tissue and became dammed up into large blobs of multinucleated protoplasm. These are shown typically in Fig 5.

### The possibility of primary arterial disease causing ischaemic necrosis of muscles—

In view of the suggestion confidently put forward by Horn (1945) that chronic arterial disease preceded muscle necrosis, careful study was made of these sections by which to substantiate or refute this view. Two changes may be seen in the vessels included in the sections: first, there is thickening of the media, associated with a narrow lumen; second, there is diffuse perivascular cellular infiltration. One large vessel in Case 1 showed generalised intimal thickening. The clinical features in Case 3 suggested that arterial disease such as periarteritis nodosa

might have been responsible for the infarction, but there was no histological confirmation.

The vascular abnormalities we have found can be explained fully as secondary changes. Death of functional muscle, and its replacement by avascular fibrous tissue, greatly reduces the vascular bed to be supplied. Small vessels naturally undergo involutionary thickening

with narrowing of their lumina. Similar involutionary changes are known to occur in the uterine vessels after parturition, and in the umbilical cord after birth. Furthermore, with so much tissue necrosis, much of the cellular infiltration will be approximated to the vessels. It is of course recognised that sections of muscle tissue seldom contain larger vessels, but even the illustration of the anterior tibial vessels in Horn's article does not offer convincing evidence of primary arterial disease. The biopsy was taken sixteen days after the onset of necrosis, the lumen of the

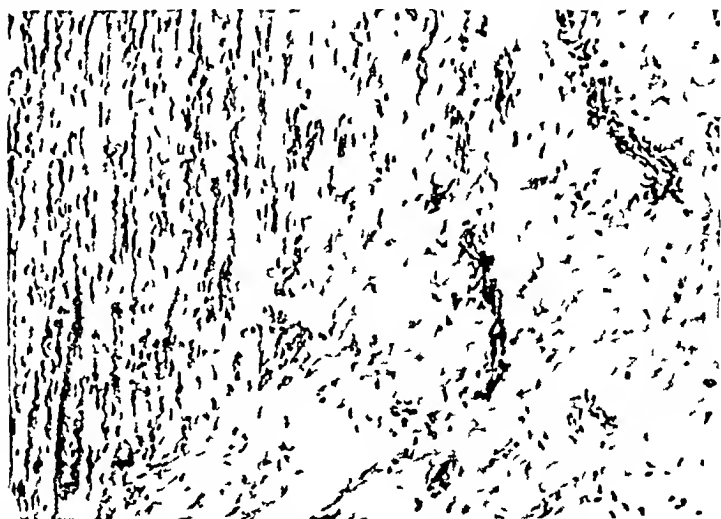


FIG 3

Case 3 Replacement of muscle by dense fibrous tissue ( $\times 100$ ). The changes are exactly similar to those in Volkmann's ischaemic contracture.

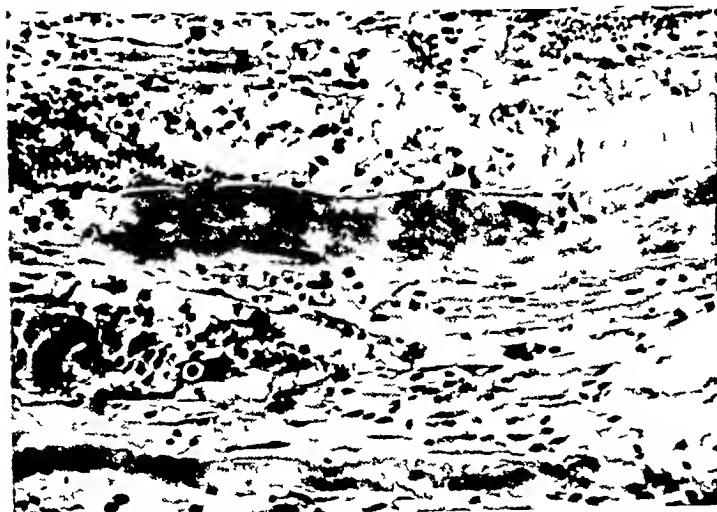


FIG 4

Necrotic fibres after twenty-one days: fragmentation, phagocytosis by giant cells, replacement by delicate fibrous tissue; note persistent cross striations ( $\times 175$ ).

artery was narrowed, the media was obviously thickened, and both artery and vein were matted together in fibrous tissue. The artery at operation was found to be surrounded at one level by a mass of firm grey tissue. These changes might well have been secondary



to involvement of the vessels in the dense mass of fibrous tissue which had formed by that time. Summarising, I do not think there is anything in the histological picture which can be regarded as the cause of the muscle damage.

**Pathogenesis**—Study of the morbid anatomy in these cases indicates that necrosis and contracture of the muscles is the result of acute arterial insufficiency. It is well known that, in advanced arteriosclerosis of a limb in which there is peripheral gangrene, there may be complete occlusion of the femoral artery in the adductor canal and yet no more than moderate atrophy of the muscles below the knee. Occlusion of the main artery of supply will not, alone, cause muscle necrosis, the occlusion must occur rapidly and it must be maintained



FIG 5

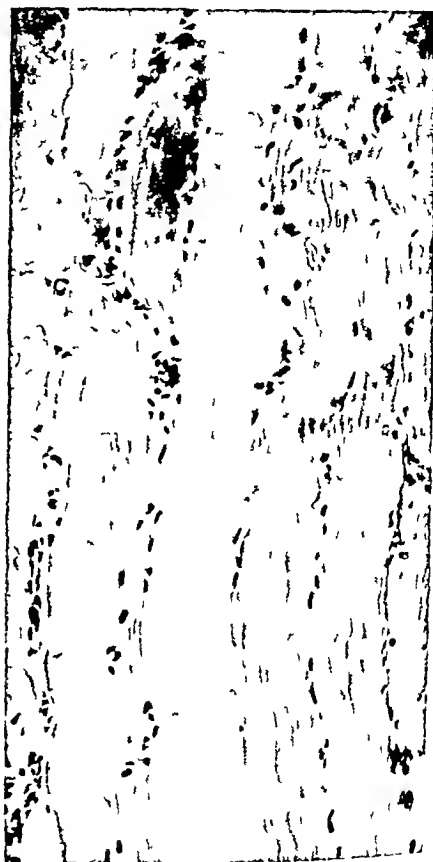


FIG 6

Fig 5 shows regenerating fibres of the anterior tibial muscle after necrosis in Case 1. Note the size the nuclei and the terminal blobs ( $\times 280$ ). Fig 6 is a section from the normal gastrocnemius in the same case ( $\times 150$ ).

for six to twenty-four hours (Lewis 1936, Cohen 1944). Such a state could, theoretically, be brought about by extraluminary occlusion (mechanical compression or kinking) or by intraluminary occlusion (embolism, thrombosis, or spasm). Until the nature and anatomical level of such occlusion can be deduced, pathogenesis must be a matter of speculation.

*Anatomical considerations in relation to vulnerability of the anterior tibial group of muscles*—We may wonder why it is that the anterior tibial muscles should be so susceptible to infarction. It is not entirely a question of special demands during activity, for Case 3 illustrated bilateral involvement while the patient was confined to bed. Nor is it simple coincidence that the tibialis anterior muscle should bear the brunt of the attack, while the extensor digitorum longus muscle often escapes so lightly, it is the logical sequence of their vascular pattern.

**Blood supply of the anterior tibial muscles**—Campbell and Pennefather (1919), in an excellent paper, showed that intramuscular anastomoses were so fine that the main muscular branches could be regarded functionally as end-arteries. More recently the vascular pattern of individual muscles has been worked out carefully by Blomfield (1948) using radio-opaque injection media. I am greatly indebted to him for detailed observations on the blood supply

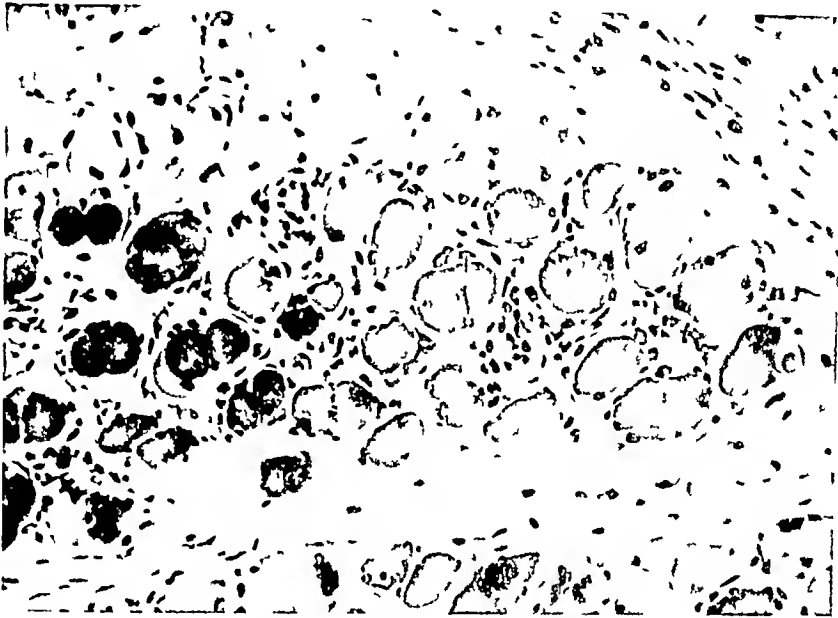


FIG 7

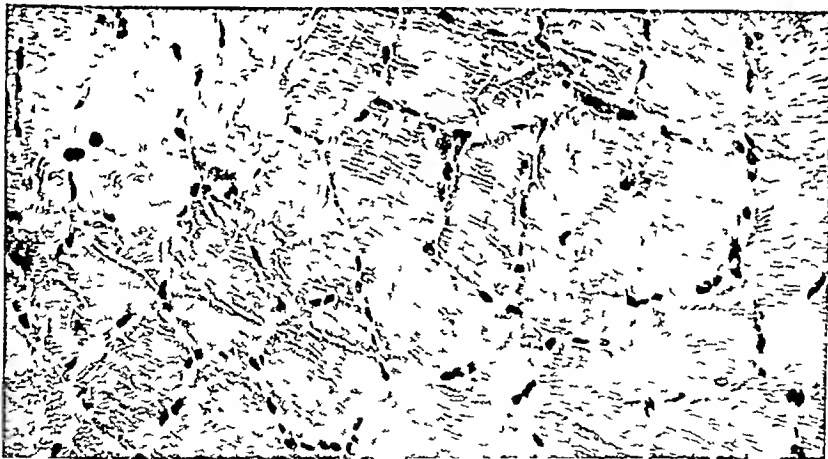


FIG 8

Fig 7 is transverse section of the regenerating muscle fibres in Case 1. Note the endomysial proliferation and variation in size. Fig 8 is a transverse section of the normal gastrocnemius ( $\times 260$ ).

of the anterior tibial muscles, much of which is still unpublished. The major blood supply of muscles of the anterior tibial compartment\* is from the anterior tibial artery, which emerges between the two heads of the tibialis posterior muscle. Vogt (1943) suggested that the vessels might be injured by sliding contact with the edge of the interosseous membrane.

\* The term anterior tibial compartment refers to that fascial compartment containing the tibialis anterior and the two long extensors of the toes.

This has not been substantiated in my anatomical dissections which indicated that as the vessels pass forwards they are surrounded by a cuff of loose areolar tissue and are cushioned by muscular fibres the free edge of the interosseous membrane being situated at least one to two centimetres distally.

The tibialis anterior muscle is supplied almost entirely by the anterior tibial artery through a series of segmental branches approximately twelve in number, which divide into ascending and descending divisions anastomosing by a system of arcades (Le Gros



FIG 9

Cadaveric injection showing the normal vascular pattern of the anterior tibial muscles in a patient aged twenty-three years. The tibialis anterior is to the right. Radio opaque suspension was injected into the femoral artery and the anterior tibial muscles then removed *en bloc*.



FIG 10

Vascular pattern of the left anterior tibial muscles injection into femoral artery after ligation of the anterior tibial artery at the level of its recurrent tibial branch. Note retrograde flow (Patient aged seventy-nine with bilateral Paget's disease of the tibiae.)

Clark 1946, Blomfield 1948) The proximal third of the muscle is supplied by a leash from the anterior tibial recurrent artery. My own observations on injected specimens, cleared by Spalholz' method, tend to confirm the view of Campbell and Pennefather (1919) that intramuscular anastomoses are so fine that their functional significance is open to doubt.

According to Blomfield (1945, 1948) the extensor digitorum longus has a threefold supply 1) from the anterior tibial artery and its recurrent branch, 2) by three large perforating branches from the posterior tibial artery, and 3) by a large branch to the lower

third of the muscle from the perforating peroneal artery. These branches anastomose throughout the length of the muscle. The extensor hallucis longus has a twofold supply 1) from the anterior tibial artery, and 2) from the perforating peroneal artery. The intramuscular anastomosis is described as rectangular and of a less efficient type (Le Gros Clark 1946).

Assuming these observations to be correct we should expect that sudden complete occlusion of the anterior tibial artery, as it enters the anterior compartment, would deprive



FIG 11

Vascular pattern of right anterior tibial muscles (same case as Fig 10), injection into femoral artery after ligation of anterior tibial artery both proximally and distally (see text). Note partial filling of anterior tibial artery through the perforating branches supplying the toe extensors.



FIG 12

Incomplete filling of the anterior tibial artery ligated proximally and distally, note very little flow into the muscles. Injection of radio opaque suspension into the femoral artery after ligating the anterior tibial artery both proximally and distally shows incomplete filling of the main vessel and very little flow into the muscles.

the tibialis anterior of its entire blood supply and result in total necrosis. The extensor digitorum longus and extensor hallucis longus, on the other hand, having an additional blood supply from perforating arteries, might be expected to escape more lightly, the greater involvement of the long extensor of the big toe being explained by its relatively poor anastomotic network within the muscle.

It will be remembered that in two cases the clinical findings suggested that the proximal third of the muscle bellies was affected minimally. The inference to be drawn, I think, is

that occlusion of the anterior tibial artery probably occurred distal to its tibial recurrent leash, this was certainly so in the only recorded case in which the artery was seen (Case 2).

The extreme rarity with which there is gangrene or necrosis of the peroneal muscles is accounted for by the extensive blood supply which they receive from the peroneal artery.

**Tension within the fascial compartment**—Much stress has been laid on the rigidity of the walls of the anterior tibial compartment and the resulting vulnerability of its content to circulatory disturbances. Little point has been made of the fact that this fascial space is not closed at its lower end. Blomfield quoted a case reported by Zachary in which ischaemia of the anterior tibial muscles was said to have occurred after severe swelling within the fascial space. Others have been mentioned after direct blows and haematoma formation.

Lewis (1936) showed that much lower pressures than were required to collapse the main artery might result in complete arrest of the blood flow when applied directly to the muscle. Thus pressures of 50 to 60 mm Hg, applied directly to the muscle and maintained for twenty-four hours, might produce necrosis, whilst in animal experiments the same result were produced within six to ten hours. Prolonged activity of a muscle may increase its weight by 20 per cent, the bulk being increased by the retention of excessive fluid within the tissue spaces (Wright 1936). If for this, or any other reason, tension within the fascial compartment rises, the circulation within the intramuscular vascular networks must be embarrassed. But it must be assumed that such tension, being within a confined space, will be distributed uniformly and that all branches of the network, whether arising from the anterior tibial artery or from perforating branches, will be affected equally. On the other hand, raised pressure sufficient to obliterate the main vessel against an unyielding interosseous membrane would be more than enough to obliterate all intramuscular capillaries and give rise to uniform necrosis of all these muscles.

Sirbu, Murphy, and White (1944) described an example of ischaemic necrosis occurring five days after repair of a small hernia of the anterior tibial muscles. In such a case it is difficult to avoid the conclusion that tension played some part. The writers themselves suggested that it may have initiated arterial spasm. Nevertheless, if increased tension within the fascial compartment was the main factor in producing spontaneous ischaemic necrosis, it would be difficult to explain the susceptibility of individual muscles of the anterior tibial group, and the tendency for the proximal third of the tibialis anterior to escape.

**Intraluminal vascular obstruction**—The possibility of extraluminal occlusion, both in relation to the main artery and to the finer anastomotic branches, has already been discussed. It remains to consider embolism, thrombosis, and arterial spasm, as the possible causes of intraluminal obstruction. In none of the recorded cases has cardiac disease or other source of embolism been demonstrated. Furthermore, the anterior tibial artery arises from the popliteal trunk almost at a right angle, an anatomical feature which would not favour lodgement of an embolus. Learmonth (1944) described localised thrombosis of indeterminate origin affecting the main arteries of the limb, but his cases were of gradual onset and they bore little resemblance to the cases under consideration.

The evidence in favour of underlying primary arterial disease, with or without thrombosis, is not convincing. At this age, thromboangitis obliterans and periarteritis nodosa are the two most likely conditions, the former being more likely to affect vessels of the calibre of the anterior tibial artery and to occur unilaterally. Indeed Professor G. R. Cameron, in a personal communication, subscribed to this view. Case 3 in this series presented many of the clinical and histological features of periarteritis nodosa. But this disease affects the smaller vessels, and in order to produce the widespread necrosis which was observed, it would necessarily have involved most of the segmental muscular branches of the anterior tibial artery—which was not the case in any of the sections examined. In two recorded cases there was a history of previous aching in the anterior tibial region for some months, but apart from this there

had been no symptom suggestive of underlying vascular disease. If the main vessel or its muscular branches were obliterated, one would have expected that muscle cramp or pain would have occurred during strenuous exercise, as a premonitory symptom before the onset of ischaemic necrosis.

#### INVESTIGATIONS ON CADAVERS AS TO THE VASCULAR PATTERN OF THE ANTERIOR TIBIAL MUSCLES

Investigations were carried out with the object of establishing the effect of arterial occlusion on the vascular pattern of the anterior tibial muscles. 1) Controls of the normal pattern were made by injecting radio-opaque suspensions, of the same viscosity as blood, into the femoral artery at a pressure of 140-200 mm Hg. The anterior tibial muscles were removed *en masse*, their separate portions were defined and X-rayed. The muscles were then cleared, using Spaltholz' method, and the findings were confirmed (Fig 9). 2) Adopting the same technique, injections were made into the femoral artery after ligating and dividing the anterior tibial artery at the level of the anterior tibial recurrent branch. 3) The same procedure was carried out after ligating and dividing not only the anterior tibial artery at its anterior tibial recurrent branch, but also the artery two inches proximal to the ankle joint. 4) Injections were made after ligation and division of both anterior and posterior tibial arteries, thus completely cutting off the blood supply of all three muscles. 5) The anterior tibial muscles were carefully removed in one piece together with the anterior tibial artery, the artery was then injected with a radio-opaque suspension after first ligating it one and a half inches below the point of injection. The procedure was repeated at distances of three inches, four and a half inches, and six inches distal to the point of original injection (Fig 13).

**Findings**—The vascular patterns of these muscles varied with age, and they varied in different individuals. The older the subject the finer, and the more tortuous, was the intramuscular network. One subject, aged seventy-nine years, who had Paget's disease of both tibiae, exhibited a particularly generous vascular network.

Certain facts were established. 1) Occlusion of the anterior tibial artery as it enters the anterior fascial compartment does not deprive the muscles of their entire blood supply, there is often a retrograde flow from below, which is distributed to the three muscles it supplies (Fig 10). 2) Ligation of the anterior tibial artery proximally, and also distally in order to cut off the retrograde flow, still results in seeping of blood into the intervening arterial segment which is, however, insufficient to be redistributed in significant degree to the tibialis anterior. This incomplete filling must occur through the perforating branches which pierce the extensors of the toes and sometimes effect almost direct communication with the anterior tibial trunk. The extent of the alternative supply appears to be variable. In some it is considerable and no doubt sufficient to maintain viability of the toe extensors (Fig 11). In others, although partly filling the anterior tibial trunk, it contributes little to any of the muscles (Fig 12). 3) Injections of the anterior tibial artery after ligation at successive levels confirms the segmental vascular arrangement and suggests that the longitudinal arcade anastomosis may not have much functional significance (Fig 13A, B, C).

The critical level of obstruction of blood flow which causes necrosis is not known, but it would seem that a localised complete occlusion of the anterior tibial artery is unlikely to cause necrosis, on the other hand a longer segmental occlusion of the vessel, such as may be produced by arterial spasm, would obliterate the main channel by which retrograde distribution through the segmental branches may be brought about. The alternative blood supply to the two extensors through perforating branches may be sufficient in some cases to preserve their viability but quite apart from this their smaller bulk tends to minimise the degree of contracture which can be detected clinically.

**Relationship to exercise**—The relationship of exercise to acute ischaemia of the anterior tibial muscles is so striking a feature that it demands consideration. Horn (1945) ingeniously surmised that "hypertrophy and fibrosis of the media of the anterior tibial artery" which he believed to be an essential underlying vascular change, was a result of the repeated and overwhelming demands of muscles during strenuous exercise. He believed that involvement of the adventitia in this fibrosis caused reflex vasoconstriction "affecting the entire collateral network" and that the circulation was further impaired by muscular swelling due to chemical and histological changes as described by Howard (1937) in crepitating tenosynovitis. This hypothesis does not, however, bear critical scrutiny. No artery narrows its lumen in response



FIG 13

A, B, and C show the vascular pattern after ligation of the anterior tibial artery  $1\frac{1}{2}$  inches, 3 inches and  $4\frac{1}{2}$  inches respectively from the point of injection (see text) note the segmental nature of the blood supply

to increased demands by the area it supplies. The normal vascular response to muscular activity is one of diminished peripheral resistance with an increased capillary bed. There is no hypertrophy of the media, such a change, if it occurred, would be more in keeping with prolonged arterial spasm. Secondly, the tibialis anterior has no collateral blood supply other than its segmental branches, and even in those muscles which have an alternative supply the intramuscular networks are probably under humoral rather than autonomic control. Thus spasm, even if segmental, does not presuppose involvement of a collateral field in order to produce complete ischaemia.

Whatever condition may be responsible for acute ischaemia it must have persisted for six

to twenty-four hours in order to produce necrosis (Lewis 1936, Cohen 1944), and there is clinical evidence that the resulting inflammatory reaction occurs about twelve to twenty-four hours after the strenuous exercise, suggesting that vascular insufficiency began during the physical effort, or probably shortly after it. In Case 1 and Case 2 in this series the onset appears to have been after exercise, on the other hand Horn's cases suggest onset during the exercise.

It may be urged that complete vascular occlusion need not be assumed, and that the ischaemia is relative rather than absolute. Demands upon the vascular supply may be in excess of that which it can provide, for the metabolism of muscle in activity is greatly increased, and if exercise is more strenuous than is customary for the individual, the power of oxygen abstraction is appreciably diminished (Wright 1936). The muscle is subjected to relative anoxia and necrosis supervenes. The analogy to this would be the ischaemic limb in which gangrene is precipitated by increasing the metabolic demands of its tissues. Such a view is hardly tenable when one realises that in order to produce muscle necrosis the oxygen deprivation would have to persist much longer than the period of muscular exercise to which the patients were subjected. Nevertheless, I think that relative anoxia during strenuous and unaccustomed exercise is probably an important secondary factor in tipping the scales in favour of necrosis. The local accumulation of lactic acid, and its coagulative action on muscle fibres as described by Albert and Mitchell (1943), whether it be the result of venous obstruction or of arterial insufficiency, is merely the means by which anoxia effects necrosis.

In the light of present knowledge it seems that the most likely primary cause of spontaneous ischaemia is spasm of a large segment of the anterior tibial artery, beginning just below its anterior tibial recurrent branch. Is it possible that the marked chemical and pH changes which are known to occur in fatigued muscles, and in tenosynovitis, could initiate this spasm? It is known that muscle break-down products in ischaemia, particularly adenosine derivatives, are capable of producing spasm of the renal vessels (Green and Stoner 1945), and it may well be that accumulated metabolites in fatigued muscle are capable of a similar action locally. Tension within the anterior fascial compartment is probably an aggravating factor. Arteriography, or exploration within the first twelve hours after exercise, may provide the answer.

#### TREATMENT

Advance in our knowledge of curative treatment depends upon early diagnosis. The obvious difficulty lies in the fact that if there is delay, irreversible damage has already been done by the time that inflammatory changes become evident clinically. The object should be to relieve arterial spasm before necrosis supervenes. Early eupaverine injection might be helpful, but the effect of paravertebral block on muscle circulation is still debatable. Assuming that a case is seen within the first twelve hours, exploration appears to be warranted. The operative approach should be between the muscles rather than through them. Care must be taken to avoid damage to intramuscular branches. The fascia cruris should not be repaired. If there is arterial spasm the appropriate treatment should be employed but it must be borne in mind that arteriectomy should be limited to resection of a very small segment, the part of the tibialis anterior muscle which will be deprived permanently of its blood supply is directly proportionate to the length of arterial segment excised. The danger of exploring muscles after necrosis has supervened cannot be over-emphasized. Necrotic tissues are prone to infection and gangrene, and in one case amputation was necessary (Sirbu *et al* 1944).

Whatever treatment may be undertaken during the first twenty-four hours, the limb should be supported with the ankle in the mid-position and free from constriction. This position should be maintained until the acute inflammatory reaction has subsided and until there is no longer any tendency to further contracture. Subsequently a toe-elevating spring should be worn for the first few months of weight-bearing. Surviving muscle fibres should be redeveloped by graduated exercise.



## SUMMARY

- 1 Three cases are reported of ischaemic necrosis of the anterior tibial muscles which were not due to injury. In two, ischaemia was the result of strenuous or unaccustomed exercise in young adults, in the third it was an incident in a systemic disturbance. All three cases were probably the result of spasm of a large segment of the anterior tibial artery.
- 2 The clinical features during the first few hours resemble those of tenosynovitis of the tibialis anterior, and after twelve to twenty-four hours those of cellulitis of the leg. Later there is "drop foot" due to muscle weakness, contracture limiting plantar-flexion movement, and woody hardness of the muscles in the middle third.
- 3 The morbid histology is similar to that of Volkmann's ischaemic contracture.
- 4 The possible explanations—primary arterial disease, arterial occlusion by pressure of the interosseous membrane, occlusion by tension within the fascial space, intraluminary occlusion by embolism or thrombosis, and fatigue arterial spasm, are discussed.
- 5 The vascular pattern of the anterior tibial muscles has been studied by experimental injections in cadavers.
- 6 It is concluded that the most likely cause is spasm of the anterior tibial artery due to muscle fatigue, aggravated by increased tension within the anterior fascial compartment due to reaction after strenuous exercise.
- 7 Treatment is outlined. Exploration of the anterior tibial artery within the first twelve hours is warranted, but late exploration may be dangerous.
- 8 Although not previously recognised, evidence is shown that regeneration of necrotic muscle is possible in the human being.

I wish to express my thanks to Sir Reginald Watson-Jones for his encouragement and to him and Mr H. Osmond-Clarke for permission to publish these cases, to Dr Harrison, Professor G. R. Cameron, and Professor Le Gros Clark for their advice on histological material, in particular to Dr Blomfield for access to unpublished work on the vascular pattern of muscles, to Mr R. Tucker-Lady Jones Research Fellow in Liverpool for injection facilities and for valuable help and criticism, and to Mr John King of the London Hospital to whom I am indebted for the microphotographs.

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# DEVELOPMENTAL COXA VARA

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Excellent papers have appeared from time to time on the subject of developmental coxa vara, sometimes under the titles of congenital, infantile or cervical coxa vara. Despite this fairly extensive literature, and probably because the condition is not common, its real nature and severity have seldom been recognised as soon as they should be, and treatment has not usually been started until there was marked deformity. The condition is characterised by the development, at the age of about three or four years, of a limp or waddle which is usually painless and is progressive. A varying degree of coxa vara deformity is present on one or both sides, but the most striking feature is the radiographic appearance of a gap in the neck of the femur just distal to the epiphyseal line, together with a bend in the femoral neck at this level. This X-ray appearance is in itself almost sufficient to establish the diagnosis as soon as the patient is first seen.

*Frequency*—The condition is rare, and few large series of cases have been reported. Statistics of the Hospital for Sick Children, Toronto, show that in twelve years, 1936 to 1947 inclusive, fifteen patients with developmental coxa vara were admitted. In the same period 197 new patients were admitted with congenital dislocation of the hip joint. Thus we have seen one case of coxa vara for every thirteen cases of congenital dislocation. It is to be noted, however, that congenital dislocation of the hip joint does sometimes run in families and that it is more common in some districts than others. Moreover, developmental coxa vara may also run in families. It is possible, therefore, that in comparing the incidence of developmental coxa vara with that of congenital dislocation of the hip joint our ratio of one to thirteen may be different from that of other clinics.

*Familial tendency*—This paper is based on fifteen cases admitted to the Children's Hospital, Toronto, and one other case which was first seen at the age of forty-three years. Of these sixteen patients, eight were males and eight were females. In ten, the condition was present on one side, in six, both hips were involved. Of the sixteen patients, four were related: two were brother and sister, and two others were second cousins of these first two. They all had other brothers and sisters, none of whom had any limp. One uncle who was reported to have had a limp could not be traced. None of the other twelve patients were related and none gave any history of a limp in the family.

## CLINICAL HISTORY AND PHYSICAL SIGNS OF DEVELOPMENTAL COXA VARA

*Clinical history*—The clinical history was somewhat the same in all cases. In a few, the limp or waddle was noticed when the child first began to walk, but in most it did not appear until the age of three or four years, the gait being apparently normal before that age. The limp was not preceded by any severe injury and it was usually painless. At first it was very slight, but it increased slowly, as a rule it was not until a year later, and usually much more than a year later, that the patients sought advice. In a few cases, long after the limp had developed, there was a history of a sudden attack of moderate pain, coming on after trivial injury, disappearing in a couple of weeks, but leaving definite and lasting increase in the limp. More commonly the limp increased gradually over a period of six or seven years and remained almost painless throughout. In cases which were first seen at a later age, there was a history of some improvement in the limp at the age of about twelve years. One patient, seen at the age of forty-three years with marked bilateral deformity (Fig 4), had developed

\* Paper read at the combined meeting of the American, British and Canadian Orthopaedic Associations in Quebec June 4, 1948.

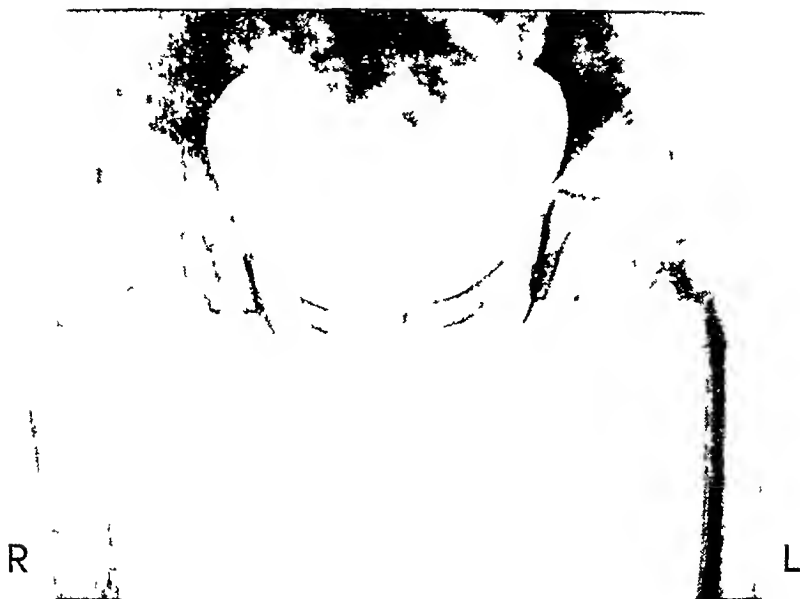


FIG 1

Developmental coxa vara age four years. On the right the gap in the bone branches away from the epiphyseal line at its lower end. On the left, it branches into two, leaving a triangular part of bone separated.



FIG 2

Bilateral developmental coxa vara first seen at the age of six years with only slight deformity and with the gap in the bone more horizontal than vertical. The appearance of 'fragmentation' is rather marked.

severe pain on one side at the age of forty years, probably because of arthritic changes in the altered hip. The pain was much improved by subtrochanteric osteotomy.

**Clinical examination**—Physical examination of these patients showed no abnormalities except those which were attributable to the condition of the hips. Most patients were rather short in stature, shorter than other members of the family at the same age, but not to marked degree. None showed signs of rickets. There was elevation of one or both trochanters with limitation of abduction movement, the degree of limitation depending on the degree of coxa vara deformity. When this deformity was severe, there was also limitation of

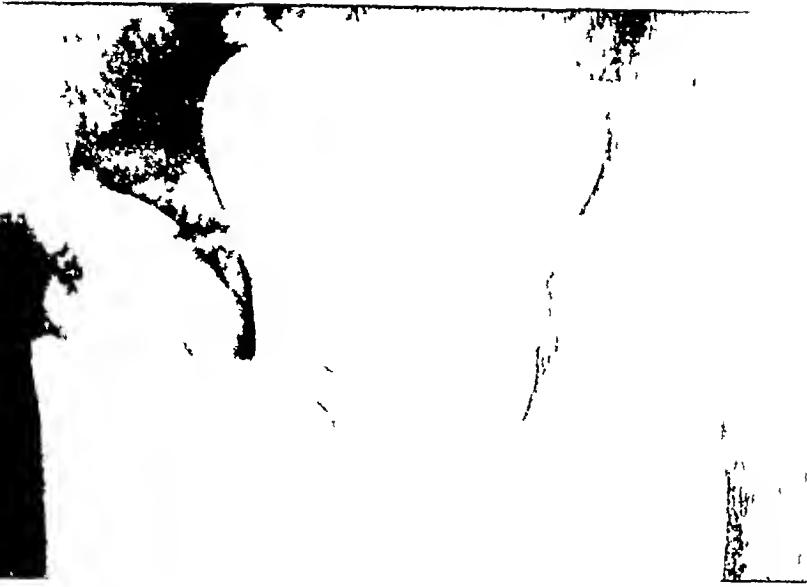


FIG 3

Developmental coxa vara seen at the age of eight years with rather marked deformity and shortening of neck, particularly at its lower margin thus giving an impression of collapse of the tissues forming it



FIG 4

Developmental coxa vara first seen at the age of forty-three years no treatment. The gap in the bone has closed, but with marked deformity. The gait was good but there was pain on one side during the last few years from secondary arthritis

extension movement of the hip, and of rotation movement in both directions, but in none was there marked external rotation deformity of the limb such as is seen in slipped epiphysis. In bilateral cases there was moderate lumbar lordosis on standing. The femur below the neck appeared normal and, when only one side was involved, the length of the two limbs as measured from the trochanters was the same.

In early stages the children did not complain of pain, although usually they tired easily. By the time the patient was first seen the limp or waddle was rather marked, it was greater than could be accounted for by deformity alone, and it seemed probable that to some extent



FIG 5



FIG 6

Developmental coxa vara in a patient who had no treatment. The gap in the bone shown at the age of twelve years (Fig 5) closed completely by the age of seventeen years (Fig 6) with normal looking bone but with moderate varus deformity and considerable shortening of the neck.

the limp was due to instability of the femoral neck at the gap. In older patients, when the gap in the femoral neck had healed, the gait, having regard to the severe degree of deformity, was extraordinarily good.

**Radiographic examination**—The radiographic appearances were very similar in nearly all cases. Even in early stages, when the child first began to limp, a gap in the bone was already obvious (Fig 1). It crossed the neck of the femur distal to the epiphyseal line. In most cases it ran part of its course parallel to the epiphyseal line, but towards one end, usually the lower end, it branched away from it, and in some cases, also usually at the lower



FIG 7



FIG 8

Bilateral developmental coxa vara at the age of three years (Fig 7) and at the age of sixteen years (Fig 8) in a patient who received no treatment. The gap in bone closed completely but with marked deformity. Nevertheless the gait was extraordinarily good.

end, it divided into two, leaving a triangular portion of bone more or less isolated. The gap was not broad and it did not follow a straight line with clear-cut edges, the margins were usually uneven. The bone was abnormal in appearance, particularly just distal to the gap, irregular areas of greater density alternated with areas of lesser density, thus giving rise to the appearance which is often described as "fragmentation." In no case was there increased density of the femoral head suggesting necrosis of the bone such as may occur in slipped epiphysis, or in fractures at this level. As a matter of fact the density of the head was often less than normal. The epiphyseal line was usually narrow, and sometimes it could be seen



FIG 9

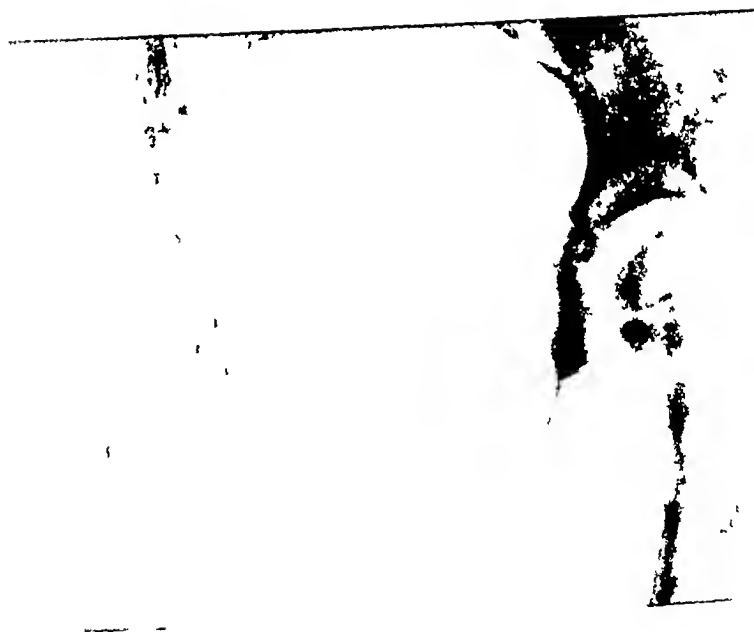


FIG 10

Developmental coxa vara in a patient, aged six years, before operation (Fig 9)  
 Same patient two years after subtrochanteric osteotomy (Fig 10) The gap  
 in the bone has closed completely There was no limp

only with difficulty It should be noted that in this condition the characteristic gap in the bone is not the epiphyseal line developmental coxa vara must not be confused with slipped upper femoral epiphysis which is more common, and in which deformity occurs at a different level and at a later age

In some early cases of coxa vara in which the deformity was not marked, the gap in the bone ran in a direction more horizontal than vertical (Fig 2) As deformity increased the head rotated downwards, and both the gap, and what could be seen of the epiphyseal line, became more vertical In most cases seen at about the age of eight years varus deformity



FIG 11



FIG 12



FIG 13

Coxa vara in patient aged five years (Fig 11) Fig 12 shows radiograph two months after osteotomy Two years later the gap has not closed and the deformity has increased (Fig 13) probably due to insufficient abduction at the osteotomy

was rather marked, and the neck was short, particularly at its lower margin, thus giving the impression that there had been collapse of the tissues forming it (Fig 3) In cases seen at about the age of twelve years the appearance of bone fragmentation was less marked and the gap was narrower In the three cases which were seen at the age of more than sixteen years the gap had bridged completely and the neck was in one piece with bone of almost normal texture (Figs 4 to 8) In these untreated cases, the final degree of deformity varied greatly, as a rule it went on to the extreme limit, but occasionally it never progressed beyond the right angle



## PATHOLOGY OF DEVELOPMENTAL COXA VARA

We did not remove tissue for histological examination and we cannot add information as to the origin and cause of this condition. The explanation which is generally accepted is that it is due to faulty development of the neck of the femur, with imperfect formation in cartilage, and with delayed and incomplete ossification of the cartilage. While this explanation does not entirely fit the picture it is probably the correct one. Varus deformity is no doubt caused by gradual bending of the unossified cartilage. Shortening of the femoral neck is due partly to this bending but largely to lack of growth at the epiphyseal line which is never normal in appearance and always undergoes premature fusion.



FIG 14

Bilateral coxa vara in a patient aged six years (for original condition see Fig 2) treated by nailing one side and bone grafting on the other. Radiographs eleven months after operation show considerable closure of the gap on the grafted side but little closure on the nailed side.

**Clinical course**—The usual course of the condition is well known. The gap in the bone is present at an early age. Without treatment the deformity increases slowly at a varying rate and to a varying extent over a period of years. At about the age of twelve years increase in the deformity ceases. Finally, in most cases at any rate, the gap in the bone heals, leaving a deformity which is usually severe but which sometimes is only moderate.

## TREATMENT OF DEVELOPMENTAL COXA VARA

Two factors must be considered in treatment, namely the coxa vara deformity, and the gap in the femoral neck. The deformity causes shortening of the limb and limitation of abduction movement of the hip. If it is severe it gives rise to a marked limp and should be corrected, or in some way compensated.

**Treatment by traction**—We have tried to correct the deformity by strong traction and forced abduction at the level where it takes place, that is to say at the gap in the bone. All that we have succeeded in doing is to pull the femoral head almost out of the acetabulum without changing the angle of the neck in the slightest. We have concluded that, although



FIG 15

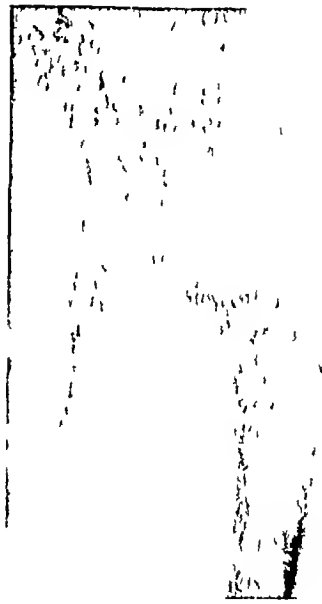


FIG 16

Developmental coxa vara in patient aged six years (Fig 15) Three months after bone grafting the gap is almost completely closed (Fig 16)



FIG 17



FIG 18

Coxa vara in a patient aged three years (Fig 17) Four months after insertion of a bone graft the gap in the bone is closing satisfactorily (Fig 18)

deformity may increase gradually, the neck is nearly always too rigid at the gap to be bent straight by closed manipulations. It seems unwise to complete division of the neck at the gap by operation, or to do an osteotomy through the neck distal to the gap, and we have not tried either.

**Treatment of late cases by trochanteric osteotomy**—Unless the deformity is very severe indeed, limitation of abduction can be overcome and shortening can be reduced by the safer procedure of osteotomy between the trochanters, or below them, the lower fragment being abducted widely. We have performed this operation on twelve hips. The osteotomy always united rapidly and the limp either disappeared or was much improved. Besides overcoming deformity, the abduction osteotomy did something else. In every case that we have been able to follow long enough, with one single exception, the gap in the bone healed completely within a year, and in a much shorter time than would have been possible without operation (Figs 9 and 10). This healing of the bone defect was probably attributable to change in the line of weight-bearing at the gap from a shearing stress to a compressive force. In the one case that did not heal, it is probable that the fragments were not abducted widely enough at the osteotomy (Figs 11–13). At the end of two years the gap was still open and the deformity of the neck had increased. Recently another osteotomy has been performed on this patient with more abduction of the fragments.

*Importance of wide abduction at the site of osteotomy*—The importance of gaining sufficient abduction at the site of osteotomy must be emphasized. This is necessary not only to secure closure of the gap in the femoral neck, but also to overcome the disability caused by deformity. The best results were obtained when the distal fragment was abducted sixty or seventy degrees at the level of osteotomy. In doing the operation, attention must be paid to the relative length of the two limbs. The affected limb is shortened by deformity of the neck. It is, therefore, wise to do the osteotomy between the trochanters, and to prevent shortening due to over-riding of the fragments, either by using some form of internal fixation or by applying traction to the limb after operation. Flexion deformity at the hip joint can be overcome at the time of the osteotomy.

**Treatment of early cases by nailing and grafting**—Abduction osteotomy is a satisfactory method of treatment for cases in which the coxa vara deformity is bad enough to require correction. It leaves a hip joint which may not be perfect in function, but which is much better than it was, and which is unlikely to get any worse for the reason that the gap in the neck is closed. It must be recognised, however, that some hips are seen before the coxa vara deformity has become at all marked, and before it is bad enough by itself to produce any limp. The diagnosis is made obvious by the radiographic appearance and it is almost certain that, without treatment, deformity will increase steadily until the gap in the bone closes. In these early cases the most important thing is to close the gap before deformity becomes disabling, and it would seem better, if possible, to do this without osteotomy which may distort the mechanics of the hip. Since healing of the gap after osteotomy seemed to be due to elimination of the shearing forces, it was thought that the same result might be obtained by the insertion of a Smith-Petersen nail. This was done in one hip of the patient shown in Fig 14. After eleven months, the gap was still widely open. In the other hip of the same patient, a few days after nailing the first hip, a large drill was passed up the neck of the femur into the head, into this drill-hole two tibial bone grafts, placed cortex to cortex, were inserted tightly. Eleven months after operation, the gap in the bone was pretty well healed, repair was much more advanced than on the side which had been treated with a Smith-Petersen nail.

Since then two other cases have been treated by grafting, in both the gap is healing well, one after three months, and the other after four months (Figs 16, 18). It would seem that this is much the best way to secure closure of the gap. The most striking thing about these

three grafted cases, one with a nail in the other hip, is that all are walking and running normally and all have lost the limp they had before operation, although there has been no change in the degree of coxa vara deformity. It would appear that weakness or instability at the site of the gap in the bone is an important element of the limp, and that if the gap can be closed before the coxa vara becomes sufficiently severe to cause disability, the symptom should disappear. The objection that at this age a bone graft across the epiphyseal line may arrest growth applies very little in these cases because in any event growth in length here will be almost negligible.

#### SUMMARY

Most of what I have said has been said before by various writers. Abduction osteotomy is the recognised form of treatment for developmental coxa vara. The results from this operation are usually good. But the results of treatment would probably be better if the condition could be diagnosed before deformity had become disabling, and if the gap in the bone could be closed by other means than osteotomy. Good results of bone grafting in early cases of developmental coxa vara are reported.

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# CONGENITAL ELEPHANTIASIS ASSOCIATED WITH CONSTRICTION BY ANOMALOUS BANDS

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Congenital constricting bands of the extremities are not uncommon. These bands may take the form of complete, or of incomplete, circles of varying depth. They vary from sloping concavities of the skin and subcutaneous fat, to sharp indentations with firm circular compression. The fingers and toes are most often affected. Multiple constrictions may be present, encircling either the digits or the limbs. Associated deformities are often found. There may be absence of part of a toe, finger, leg, or arm, or varying degrees of fusion of the digits to one another, or absence of the interphalangeal joints, with one or two long phalanges instead of three, or rudimentary phalanges with distorted interphalangeal joints, or points of deep dimpling of the skin. Unrelated congenital abnormalities may also be present, such as cleft lip and cleft palate. That all these anomalies may be present in one individual is demonstrated in Figs 2 and 3, which show a child with hare lip (photograph taken after repair), cleft palate, incomplete and complete absence of digits, fusion of phalanges, webbing of fingers, equinovarus deformity of one foot, incomplete and complete constricting bands of one leg, and points of dimpling.

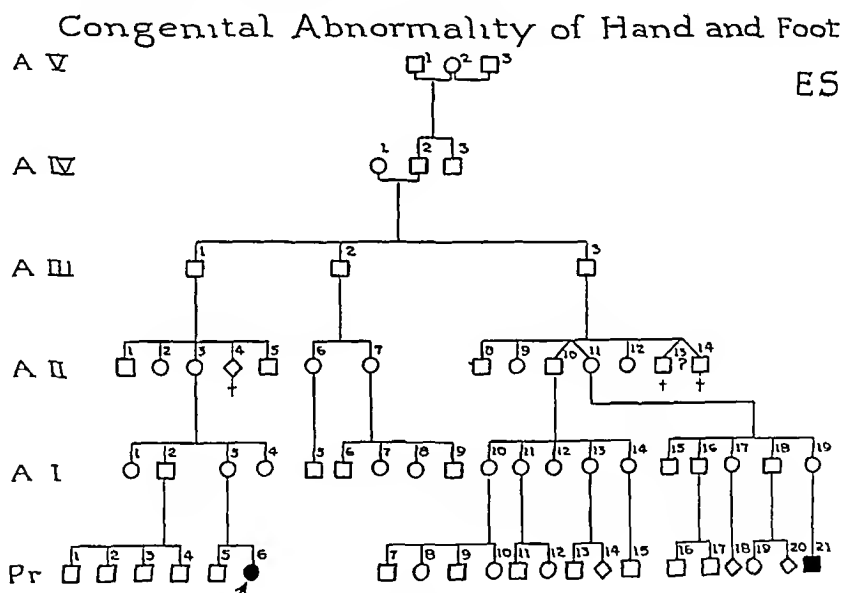


FIG 1

Pedigree of two children with marked congenital anomalies of the feet and hands one with a loose circular constriction of the forearm (see Fig 4)

**Familial and pre-natal influences**—Discussion of the pre-natal influences which bring about these deformities will not be undertaken, the author has nothing new to add. Fig 1 shows the pedigree of two children with marked congenital anomalies. One exhibited abnormalities of both feet and one hand with a loose circular constriction of the forearm (Fig 4). The other was a distant cousin who was not examined, but of whom a photograph showed absence of digits and part of the thumb of one hand. The tracing of such deformities among ancestors is a most difficult if not impossible task, demanding intense effort on the part of interested investigators, little significance must be attached to failure to secure evidence of such familial tendencies. While in one individual patient, ring-like depression



FIG 2



FIG 3

Multiple congenital anomalies in one child including hare lip cleft palate, absence of digits, fusion of phalanges webbing of fingers equinovarus deformity of the foot, complete and incomplete constricting bands of one leg and congenital dimpling

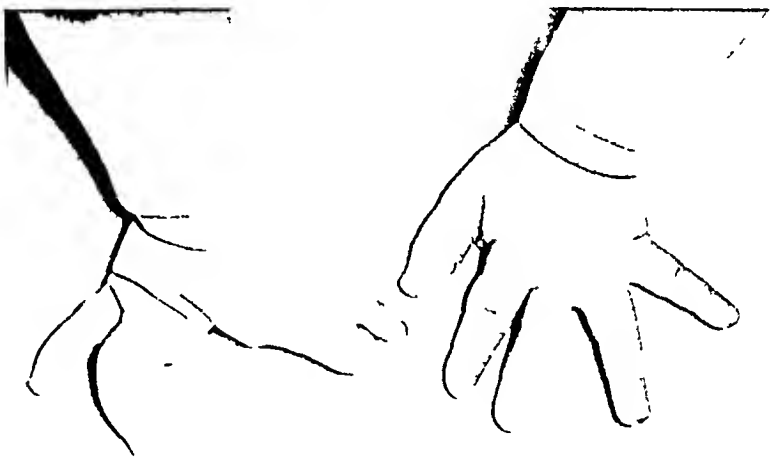


FIG 4

Congenital anomalies of the right hand with loose circular constriction of the forearm (see pedigree—Fig 1)

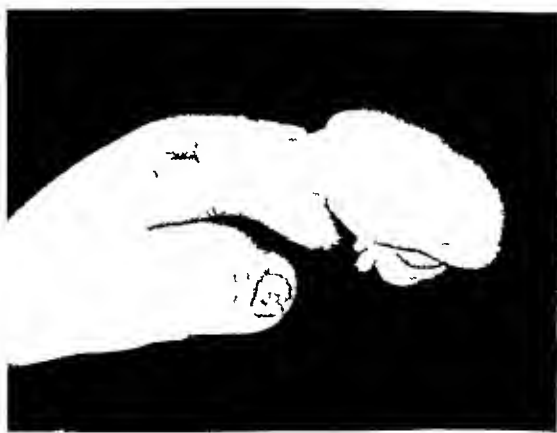


FIG 5

Constricting band of the digits with marked subcutaneous thickening of the index finger

of an extremity may be the only anomaly found, it is probably the least significant manifestation of an inherited tendency contributing to the production of a variety of more obvious and disabling deformities



FIG 6

Male child aged four months with multiple congenital anomalies of the hands and feet and with enormous swelling and lymphoedema of the left foot distal to a tight constricting band encircling the limb above the malleoli. Operative treatment was carried out as indicated in Fig 7

**Subcutaneous thickening and lymphoedema**—Distal to a constricting band there may be considerable increase in the thickness of subcutaneous tissues. This has often been noted in the fingers (Fig 5). The blood flow into such enlargement of the digits is good, and there is seldom increase in the lymph. On the other hand when there is a tight constricting band

higher in the limb, astonishing degrees of lymphoedema may sometimes occur (Bize and Giesel 1904). The chief purpose of this publication is to report the treatment of such a case.

**Case report**—A male child, four months of age, was admitted to hospital with multiple congenital anomalies of the hands and feet. There was no history of deformity in the child's ancestors. The right hand showed fusion of the tips of the middle, index, and ring fingers. In each finger there was one large and one small phalanx. The thumb had one phalanx. The left hand showed absence of the tips of the fingers with one normal phalanx for each finger. The thumb was normal. The big toe and parts of the other toes were absent from the right foot. The left foot presented a tight constricting band which wholly encompassed the limb above the malleoli (Fig 6). Below this encirclement was a tremendous enlargement. The skin was shiny and tight, and it had a transparent wax appearance. The tissues were firm. There was no pitting on pressure. After digital compression there was immediate return to the original shape. Radiographs showed very great soft tissue thickening, but there was no abnormality of the bones.

**Operative treatment**—The condition was treated by three operative procedures carried out at intervals of approximately two weeks. The first two operations were similar in nature. First, the anterior half, and then the posterior half, of the constricting band was excised. In each case a strip of tissue, one quarter of an inch wide and half the circumference of the limb, was excised in the line of the band (Fig 7). Transposition of flaps was accomplished by means of a "Z" plastic manoeuvre from the normal area above, into the abnormal area below, and vice versa. This was performed on so large a scale as to remove the indentation from the whole circumference of the limb. At a third-stage operation, skin and subcutaneous tissues were removed from the dorsum of the foot down to the deep fascia. Part of the skin was converted into a free, full-thickness graft by excision of all subcutaneous fibrous tissue. It was then replaced and a pressure dressing was applied. In one area there was some loss of skin which was replaced later by a split-skin graft.

**Laboratory examination of tissue fluid**—At the original operation, when the incision was first made, clear fluid flowed from the wound as blood might flow from a large vein. Four test tubes were filled with this liquid which on analysis showed a serum protein content of 2.2 grams per cent. Laboratory reports showed that only albumin was present. The fluid did not clot even after several hours. Microscopic examination showed no more than a few lymphocytes.

**Histological examination of removed tissue**—The great increase in thickness of the epidermis of the skin from the dorsum of the foot is shown in Fig 12. In a section of the deeper tissues large lymph channels can be seen clearly (Fig 13).

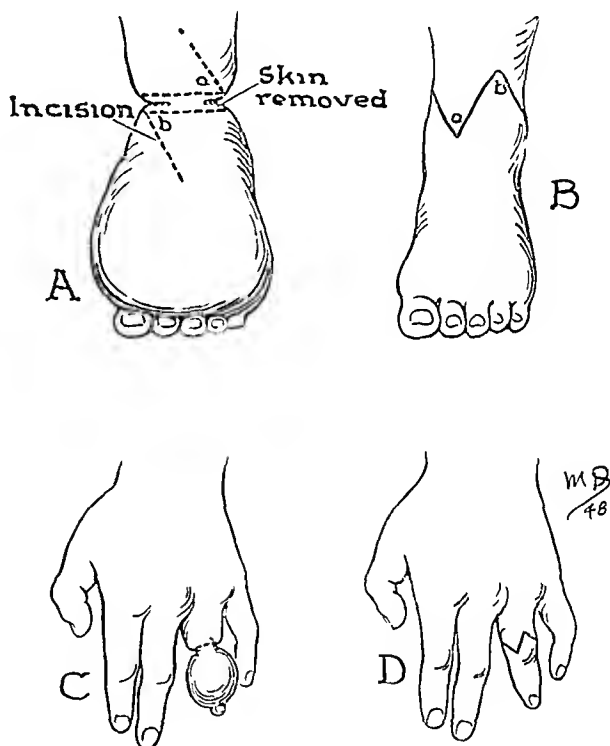


FIG 7

Z-plastic operation for removal of a strip of tissue at the site of encircling bands



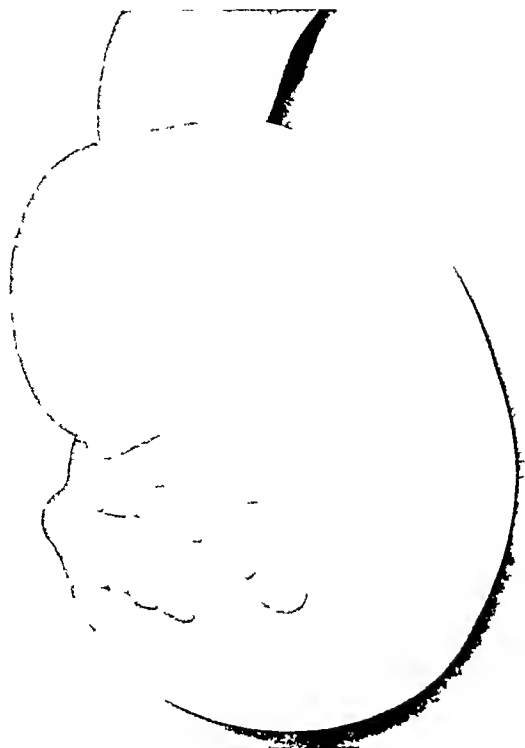


FIG 8

Photograph of the foot in the case reported before operative treatment

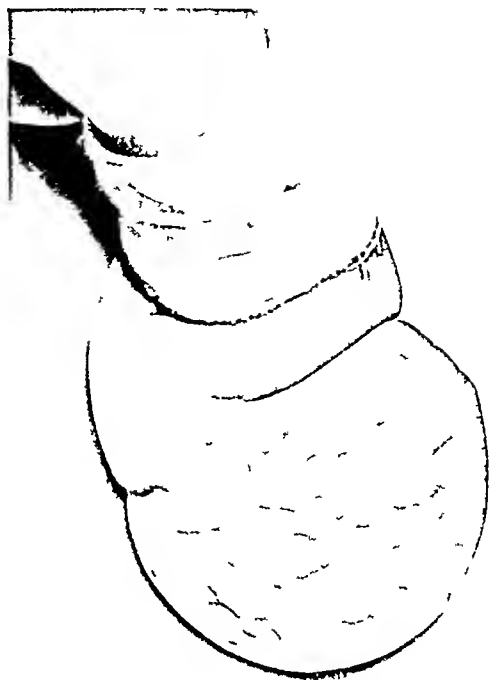


FIG 9

Within a few days of the first operation there was remarkable shrinkage of tissue



FIG 10

After the completion of operative treatment, including two "Z" plastic resections of the constricting band, resection of skin and subcutaneous tissue from the dorsum of the foot, and whole thickness and split-skin grafting, the foot is almost normal in appearance and function



FIG 11

*Post-operative course*—The condition of the foot before operation is shown in Fig 8. It was almost impossible to recognise the shape of the toes. Within a few days of the first operation there was remarkable shrinking of tissues (Fig 9). By the time the patient was discharged from hospital, after the third operative procedure, the foot was almost normal in appearance (Fig 10). Re-examination several months later showed that the cosmetic appearance was still satisfactory and function was excellent (Fig 11). There had been no recurrence of swelling or enlargement of the limb.

### DISCUSSION

Enlargement of an extremity at birth may be due to a number of factors other than constricting bands. Cooperstock (1939) indicated that the three chief causes of congenital enlargement were: 1) lymphangiectasis, 2) haemangiectasis and congenital arteriovenous

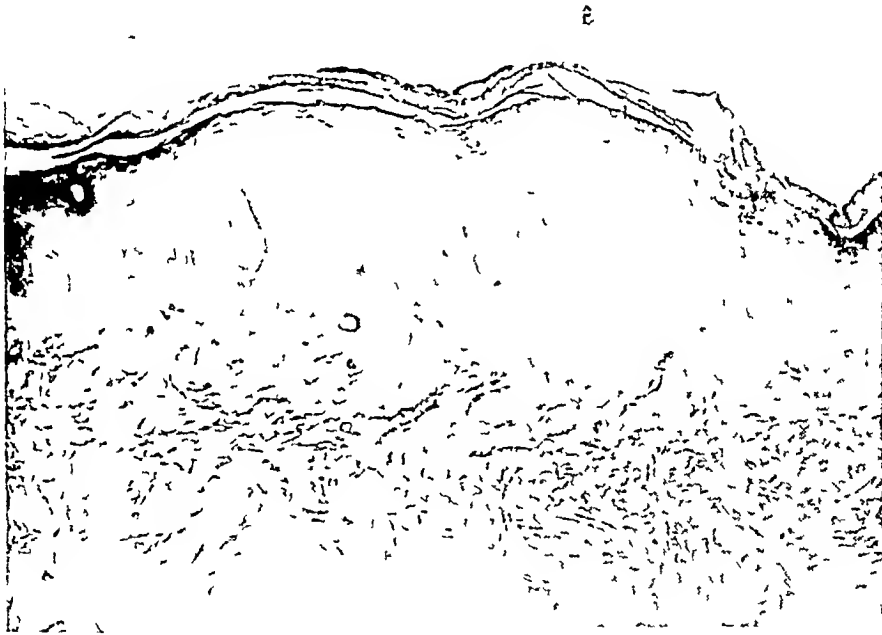


FIG 12

Section of skin from the dorsum of the foot in the case shown in Fig 6. There is great increase in the thickness of the epidermis.

anastomoses, 3) Recklinghausen's neurofibromatosis. In all forms of elephantiasis there is overgrowth of connective tissue. It has been suggested by Homans (1940) that the proteinised fluid acts as a tissue culture medium and encourages fibrosis. In the case here reported, the elephantiasis was undoubtedly due to blockage of veins and lymphatics in the region by a tight encircling indentation. It is unbelievable that this could be the result of pressure from an amniotic band about the limb. Such is discussed by Ballantyne (1902) who noted that "pictures of them are to be found in the older works on monstrosities".

The use of the "Z" plastic manoeuvre for the correction of such constrictions is not new. Ferris Smith (1946) warned against the use of incisions around the entire circumference of the constriction in cases without lymphoedema. It was indicated that in one such case swelling still persisted many years after operation.

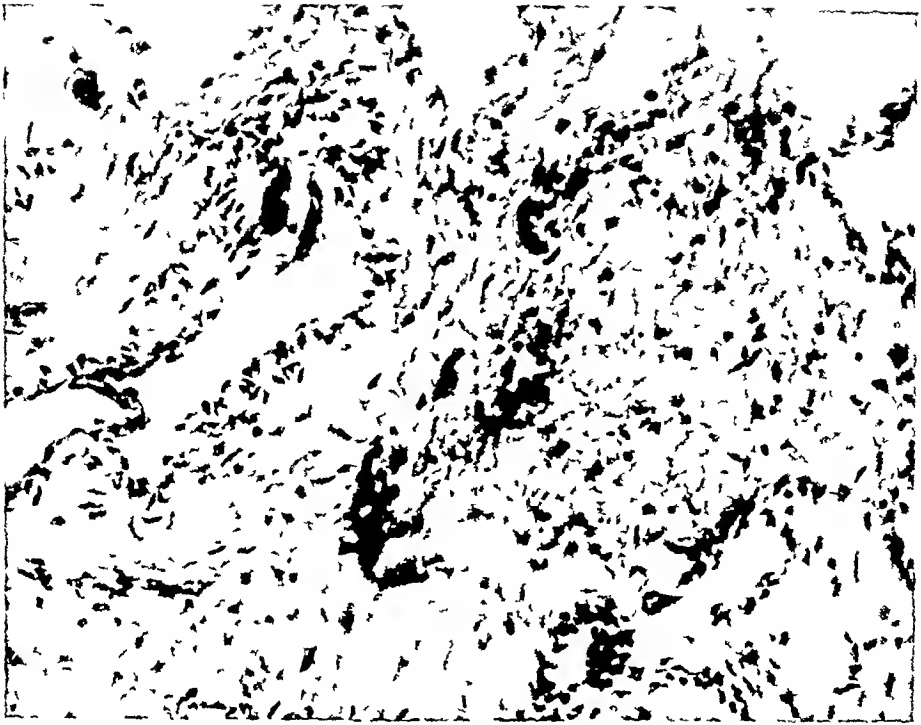


FIG 13

Section of subcutaneous and deeper tissues from the foot in the case shown in Fig 6. Large lymph channel can be seen clearly.

### SUMMARY

Congenital anomalous bands of the extremities are variable in position, depth, and in the completeness of their encirclement. They represent one of a group of abnormalities which are often present in the same individual. Cases associated with gross lymphoedema are rare. The treatment of such a case is presented.

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## SPINAL EXTRADURAL CYSTS

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Spinal extradural cysts are rare. In 1914, Good, Adson, and Abbott presented the twenty-first recorded case. In 1945, in a review of epidural lesions producing cord compression, two other cases were reported by Shenkin, Horn, and Grant. Hyndman and Gerber added a further case in 1946. So far as we know the case now reported is the twenty-fifth to be recorded in the literature.

*Two types of spinal extradural cyst*—There appear to be two distinct clinical pictures associated with spinal extradural cysts. Elsberg, Dyke, and Brewer (1934) defined the first: the patient is an adolescent with the history and symptoms of progressive spastic paraplegia, radiographic examination shows dorsal kyphosis of the Scheuermann type with signs of an expanding tumour in the neural canal in the dorsal region. This clinical type has been confirmed by Cloward and Bucy (1937), Adelstein (1941), Turnbull (1939), and Lehman (1935).

The second type occurs in adults, usually in the lumbo-dorsal spine. The cyst is not associated with dorsal kyphosis. Cloward's patient was a man aged forty-three years with a two years' history of symptoms. There was no dorsal kyphosis and radiographic examination indicated an expanding intraspinal lesion in the upper lumbar region, very similar to the case reported here. A second case of spinal extradural cyst in an adult was described by Good, Adson, and Abbott (1944). The patient was a male, aged forty-two years, with old dorsal juvenile kyphosis, who had been perfectly well for at least twenty-four years before the onset of symptoms. The cyst was lumbo-dorsal in position and did not appear to be related in any way to the kyphosis.

**Case report**—Mrs E. J. C., a European woman aged forty-two years, was in good health until one month after the birth of her first child fifteen years previously. She then developed weakness of the left leg which made her fall, even when walking over level ground. Shortly afterwards she complained of pain in the lumbar region, and cramps in the left foot especially when lying in bed. On walking, the left foot went into eversion.

Weakness and cramp in the left leg increased during the next four years, when mild symptoms developed in the right foot and calf. She again became pregnant. The backache became worse and, soon after the birth of her second child, five years after the first onset of symptoms, the pain began to radiate down the back of the left thigh.

Shortly after the onset of symptoms she had developed stress incontinence which a gynaecologist attributed to birth trauma. The incontinence increased gradually and, after the birth of the second child, perineorrhaphy and ventro-suspension were performed but without improvement.

All symptoms steadily became worse and eleven years after the onset her legs were so weak that she needed support when walking. Severe muscle cramps involved the whole left lower limb. Rising from a chair was very difficult owing to backache. There was spasticity of the left calf muscles with equinus deformity which increased her difficulty in walking.

When first seen by us, after fifteen years, she had atrophy and spasm of the left thigh and calf muscles. Voluntary power in the whole of the left lower limb was weak. The knee jerks were brisk, more so on the right than on the left. The ankle jerks were brisk and equal on both sides. There was impaired cutaneous sensation below the level of the tenth dorsal nerve root. Sense of joint position, passive movement, and vibration was absent on the left and normal on the right. There was Rombergism.

*Radiographic appearances*—X-ray films of the middle and upper dorsal vertebrae showed normal appearances. There was no wedging, kyphosis, or irregularity of disc spaces, such as are seen in old adolescent kyphosis. The lower dorsal and upper lumbar vertebrae showed definite changes. In the lateral film the vertical interpeduncular distances were increased, and the antero-posterior view showed flattening and atrophy of the medial aspects of the pedicles. The interpeduncular distances showed irregular variation in place of the

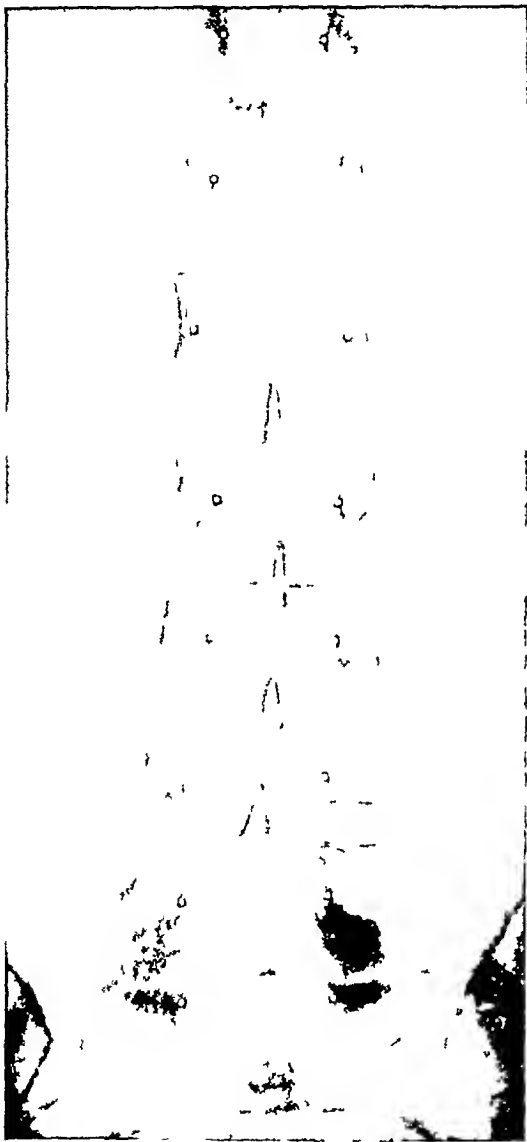


FIG 1



FIG 2

Radiographs show pedunculated erosion with increased width of the neural canal (Fig 1). The lateral view shows excavation and hollowing of the posterior surface of vertebral bodies and much enlarged intervertebral foramina (Fig 2). Note that there are six lumbar vertebrae

normal regular increase in the caudal direction (Fig 1). The tenth and eleventh dorsal, and first and second lumbar vertebrae, showed abnormal measurements

Vertebrae	D9	D10	D11	D12	L1	L2	L3	L4	L5	L6
Interpeduncular distances (in mm)	21	23	24	22	29	36	28	29	30	34

In the lateral projection there was marked hollowing of the posterior surfaces of the bodies, particularly from the tenth dorsal to the third lumbar vertebrae. Narrowing of the pedicles

in the vertical diameter, with consequent enlargement of the intervertebral foramina, was also evident in this view (Fig. 2). These findings were interpreted as indicating the presence of a large mass within the spinal canal, extending from the tenth dorsal to the third lumbar vertebrae, and causing pressure changes in adjacent bone.

*Myelographic examination*—Myelography was done by injecting 4 c.c. of lipiodol into the cisterna magna, this passed normally as far as the first lumbar vertebra where it broke up into globules (Fig. 3). The globules passed beyond the normal confines of the spinal theca and through the intervertebral foramina to lie three to four centimetres from the midline (Fig. 4). They could not be returned into the neural canal by alteration of position. In the erect position, the lipiodol partly outlined a circular mass at the level of the first lumbar



FIG. 3



FIG. 4

Myelography shows the enlargement of the neural canal (Fig. 3). The lipiodol passed beyond the normal confines of the spinal theca and through the intervertebral foramina (Fig. 4).

vertebra. This lipiodol corresponded in position to the theca, which appeared to be indented by the mass. The globules passed beyond the main obstruction at the first lumbar level but they were held up at the second lumbar vertebra. On re-examination forty-eight hours later, the globules were again observed outside the neural canal and the other features described remained constant. These myelographic findings indicated the presence of a large mass in the spinal canal, deforming the theca at the level of the first lumbar vertebra and obstructing it at the level of the second and third lumbar vertebrae. The passage of globules of lipiodol beyond the lateral limits of the neural canal suggested recesses, or diverticula, communicating by means of a narrow neck with the subarachnoid space.

*Operation*—Laminectomy from the tenth dorsal to the third lumbar vertebrae was performed. When the spinous processes were divided it was found that the bases of two had been eroded



FIG 5

Section of the wall of the spinal extradural cyst (low power magnification)

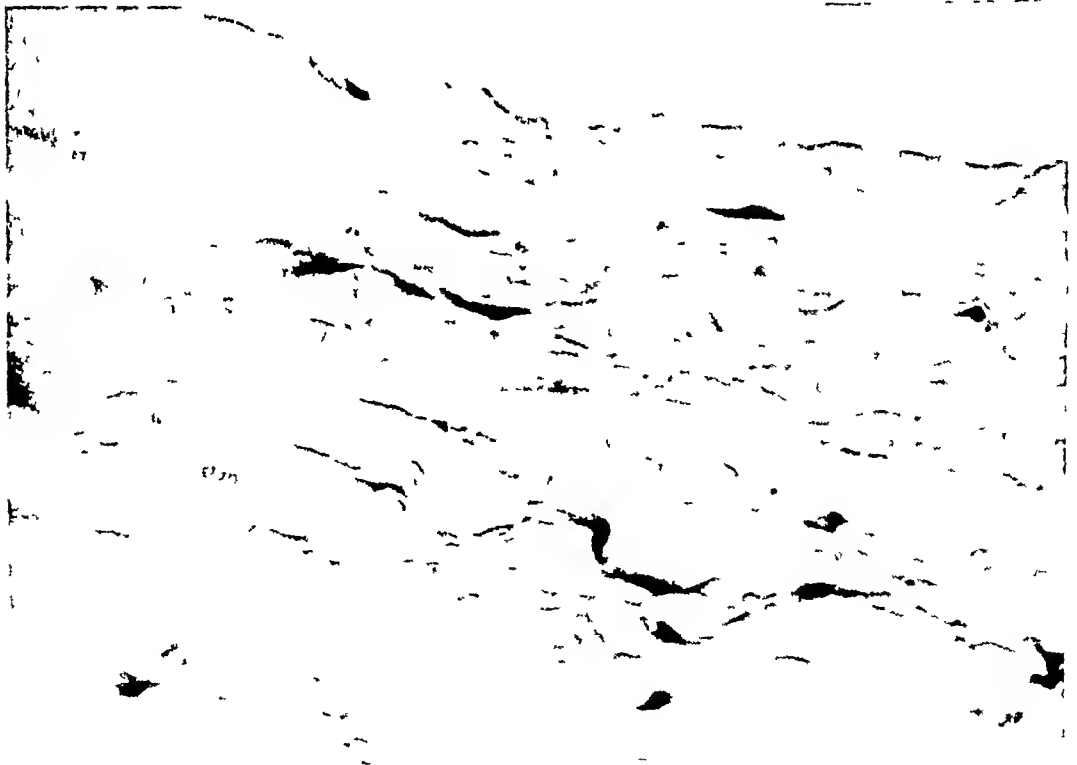


FIG 6

High power magnification of a section of the cyst wall showing its simple structure, resembling arachnoid-mater, but without endothelial lining

from inside the spinal canal, they showed smooth depressions. The laminae were very thin and could be cut with a scalpel. When they had been removed, a thin-walled cyst, blue in colour, was seen lying posterior to the dura, but extending laterally on both sides and actually protruding through the intervertebral foramina.

Closer examination showed that there were three large cysts each containing clear colourless fluid. They were very thin walled and, except at the exit of two nerve roots where the cysts were closely adherent, could easily be dissected off the dura. In this dissection the dural sac was opened and clear cerebro-spinal fluid escaped. The spinal canal was found to be very much widened. The cord and cauda equina were compressed and smaller than normal.

*Histological examination of the cyst*—Macroscopically, the specimen consisted of a collapsed cyst with a thin wall. Microscopic section showed connective tissue without any characteristic lining (Figs 5 and 6).

*Post-operative course*—After operation the spasticity of the right lower limb disappeared rapidly and that of the left lower limb more slowly. The sense of position, of passive movement, and of vibration in the left lower limb recovered gradually. After six weeks the patient walked with crutches. When last seen she was walking well, without assistance, and although there was some valgus deformity of the left foot she considered that her recovery was complete.

#### DISCUSSION

The origin of spinal extradural cysts has not been established finally. Elsberg, Dyke, and Brewer consider that "the extradural spinal cyst is due to a congenital diverticulum of dura mater, or to a herniation of arachnoid through a congenital defect in the dura." The latter hypothesis is supported by the case now reported because although the wall of the three cysts lacked endothelial lining it resembled arachnoid-mater in structure. The cysts were attached by pedicles to the dura round two nerve roots in the region of the intervertebral foramina, and though it was not possible to state whether these narrow pedicles were patent it was considered, on the basis of radiographic evidence, that at least one was open and communicated with the subarachnoid space.

Excluding the present case, four extradural cysts have been described in adults by Good, Adson, and Abbott (1944), Shenkin, Horn, and Grant (1945), and Adelstein (1941). Three were situated in the lumbar or dorso-lumbar regions and no dorsal kyphosis was present. In the fourth case there was old adolescent kyphosis but it appeared to have no relationship with the late development of a dorso-lumbar cyst (Good *et al.* 1944).

It would seem that there is a tendency for lumbar extradural cysts to become manifest at a later age than dorsal cysts. A likely explanation is that the lumbar canal is spacious, and the cauda equina is readily displaced, so that cysts may grow without giving rise to symptoms for a longer period in the lumbar spine than is possible in the dorsal region.

Cloward and Bucy suggested that "kyphosis dorsalis juvenilis may be the result of venous congestion and stasis in these vertebral bodies, whatever the cause of the vascular disturbance." They postulate that the kyphosis which is associated with an extradural cyst might be the result of obstruction of venous return by the cyst. This suggestion is not supported by the fact that there was no vertebral deformity in the four reported cases of lumbar cysts. Venous drainage of the dorsal and lumbar vertebrae is similar, and obstruction might reasonably be expected in the lumbar region with cysts large enough to produce excavation of the posterior surfaces of the bodies of the vertebrae. It is by no means generally accepted that venous congestion plays any part in the development of kyphosis of the Scheuermann type.



## SUMMARY

- 1 Two types of spinal extradural cyst are discussed 1) the type which occurs in adolescents in the dorsal spine with evidence of kyphosis juvenilis, 2) the type which occurs in adults in the dorso-lumbar spine without kyphosis
- 2 A fifth case of dorso-lumbar spinal extradural cyst in the adult without deformity is reported Cysts in this region present common features distinguishing them from the more frequent type which occurs in adolescents
- 3 The relationship between spinal extradural cysts, venous drainage of vertebral bodies, and spinal deformity, is discussed

We are grateful to Professor J Barnetson of the Department of Pathological Anatomy for the photomicrograph of the cyst wall and for his opinion on the sections

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# ARTHRODESIS OF THE ANKLE JOINT

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Some years ago I had the honour of presenting to the American Orthopaedic Association a method of arthrodesis of the subastragaloid joint for which was claimed the merit of simplicity and comparative infallibility. At the same time it was mentioned that the same principle had been used in the ankle and other joints but that sufficient time had not elapsed to justify a formal report. The results of these operations can now be considered final, and it is time that they were recorded.

It is not necessary to discuss the indications for arthrodesis of the ankle, or to dilate on the excellence of the functional results which can be expected after successful operations, for all this is well known. It has been my experience, however, that with methods commonly in use there is often failure to obtain solid, painless, bony union, and there is often regrettable increase in the deformity. An operation which involves opening the joint widely, removal of all articular cartilage, accurate fitting of the raw surfaces, and the introduction of a bone graft, is one which calls for craftsmanship and which cannot be done without some risk of infection. Furthermore, free removal of the weight-bearing articular surfaces lowers the level of the joint and may give it a thick and ugly appearance which in the case of women is objectionable. Besides this, after thorough removal of articular cartilage the astragalus no longer fits its mortice but resembles somewhat a dry pea in its pod. As a result it is difficult to hold the foot in the correct position and to maintain accurate contact of the raw surfaces in the joint during closure of the wound and the application of plaster.

To overcome these objections an operation was devised. Through two short vertical incisions, one in front of each malleolus, the ankle joint is opened and the articular surfaces are exposed. A wide thin osteotome is then applied to the lower end of the tibia and astragalus by which to cut a deep mortice about an inch and a half long and a quarter inch wide, which in its upper half is in the lower end of the tibia and in its lower involves the articular surfaces of the malleoli and astragalus. These mortices should be cleanly cut with exactly parallel walls, at least one inch deep. Through a third incision in the middle of the leg a bone graft is cut from the medial surface of the tibia, three inches long and one inch wide. This is divided transversely into two equal parts. Each is hammered solidly into one of the mortices. If they have been cut accurately the grafts should fit so tightly that the joint is then and there ankylosed in the proper degree of equinus, there is no danger of displacement during suturing of the wounds or application of the plaster.

Points to be noted in this operation are that it involves minimal exposure, that it leaves the weight-bearing articular surfaces intact and does not cause shortening, and that, unless there are complicating lateral deformities to be corrected, it can be completed in less than thirty minutes. It depends for success on the accurate fitting of two wide cortical bone grafts so placed that, when weight-bearing and walking are begun, the stresses and strains come on the grafts edgewise and so without risk of breaking them.

The results have been satisfactory. The operation has been performed twenty-five times over a period of eight years and has never failed to produce painless arthrodesis. It has been our routine to leave the original plaster in position for three months, and then to apply a walking plaster which is worn for another month. Patients usually return to work at the end of six or seven months.

When there is varus or valgus deformity the technique may require modification. Osteotomy of the fibula may be required, or it may be necessary to remove enough of the edge of a tilted astragalus to let it go back into correct relationship with the leg. Indeed,

\* Paper read at the combined meeting of the American British and Canadian Orthopaedic Associations in Quebec June 1948



FIG 1



FIG 2

Traumatic arthritis of the ankle joint with gross articular changes causing much pain (Fig 1) Radiograph three months after operation (Fig 2)



FIG 3

Radiograph of the same ankle joint as shown in Figs 1 and 2, taken four years after operation showing sound fusion

slight variations of the technique are often necessary to suit the particular case. Nevertheless the same principle is always observed, of keeping the operative interference to a minimum and depending solely on the grafts for fusion.

The changes occurring in these joints after operation have been recorded in X-rays. At first the grafts stand out sharply in contrast with the walls of the mortices. Gradually, however, the edges become blurred and the hard cortical bone becomes softened until finally, in a year or two, it is replaced completely by new bone and has become part and parcel of the bed in which it was placed. It looks as if, with the lapse of time, the articular cartilage on the weight-bearing surfaces becomes ossified so that ultimately the bones are fused throughout.



FIG 4

Colour photograph of specimen recovered by Symes amputation thirteen months after arthrodesis of the ankle by bone blocks showing solid fusion of the joint by means of the graft

We were fortunate enough to obtain a specimen thirteen months after operation which demonstrates beautifully all the gross and histological changes which occur. The specimen has been sawn in the coronal plane in order to show the relationship of the grafts to the tibia and astragalus and the solidity of fusion (Fig 4). Microscopic examination shows revascularisation and gradual replacement of the cortical graft by new bone from the surfaces.

After the remarks of our President on the desirability of more fundamental research I have felt almost ashamed to present a paper which deals solely with a problem of technique. Nevertheless, those of us who attended these meetings thirty-five years ago will recall that about that time Phemister and I were talking a lot about what happened to the bones of animals on which we were operating, and that we have been thinking and talking about these problems ever since. It is only now, after retiring from active University work, that we have time to think of some of the practical applications of the researches we did. Possibly my excuse should be that as we grow older we seek easier ways of doing our operations, and more certain methods of protecting our reputations by lessening the risk of failure.

# FATIGUE FRACTURE OF THE ULNA

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Fatigue fractures have been demonstrated in the metatarsals, fibula, tibia, shaft of the femur, neck of the femur, pubis, vertebrae, and first rib. With the exception of the first rib, these sites have in common the fact that the bones bear part of, or all, the body-weight in addition to any load which may be carried. Even in the case of the first rib it is known that a weight-bearing strain may be applied by carrying weights on the back and shoulders. Hitherto, no case has been reported of fatigue fracture of a long bone where body-weight was not an etiological factor, and although I do not think that this report of a fatigue fracture of the ulna will in any way alter or elucidate the theories already put forward as to etiology, it may nevertheless be of interest.

The patient was a well-built, right-handed, intelligent farm worker, aged twenty years. When first seen in February 1946, he complained of pain in the left forearm of three weeks' duration. There was no history of injury. The pain started while he was carting farmyard manure. He used a stable fork in filling his cart from a tightly packed heap. The pain did not prevent him from carrying on with his job. It seemed to trouble him most at night. He had difficulty in getting to sleep, but once asleep the pain did not waken him.

On examination there was fusiform swelling of the middle third of the forearm with heat, tenderness, and slight oedema. There was no creaking. There was full range of wrist and elbow movement. Radiographic examination showed a fracture of the mid-shaft of the ulna (Fig 1) which was described by Dr R Fawcitt thus: "Considerable callus formation is seen in the region of the fracture. There is periosteal reaction extending upwards and downwards along the greater part of the diaphysis of the bone. The fracture has the appearances associated with a stress fracture, or possibly a fracture due to direct violence. There is no X-ray evidence of expansion of the shaft of the bone such as occurs in bone tumours."

A plaster cast was applied from the mid-palm to the axilla, and was kept in position for ten weeks. There was then freedom from pain and no heat. A large mass of callus could be felt. Radiographic examination showed increased callus formation. Union was taking place satisfactorily, but it was not complete, and indeed the line of fracture was more apparent than in the first radiograph (Fig 2). It was considered safe at that time to leave the arm without support. No physiotherapy was used. By June 1946, four months after the first onset of symptoms, he started light work and gradually resumed normal duties. At first there was some recurrence of pain, but eventually he made a complete recovery. Radiographs in April 1947 showed faint evidence of the original fracture line, but union was soundly consolidated and the contour of the bone was restored almost to normal (Fig 3).

In deciding whether or not this was a fatigue fracture, due weight must be given to the history. Even after the most searching inquiry there was no history of a fall, blow, or other injury. Workmen's compensation was not claimed. It must be admitted that the work was heavy. During the loosening of forkfuls, and while raising them, the left hand was the fulcrum and the left forearm supported both the downward thrust of the right hand and the pull of the resisting load. The resulting strain on the left forearm was very considerable. Nevertheless no specific injury was recognised.

The similarity of radiographic appearances in this case with those of fatigue fracture of the metatarsal bones should be noted, they are unlike those of fatigue fractures of the long bones of the lower limb. The explanation may be that in the case of fracture of the metatarsal, and of the ulna, the forces act at an angle of approximately 90 degrees to the



FIG 1

FIG 2

FIG 3

Fatigue fracture of the ulna which developed without any history of injury after forking and carting farmyard manure. When first seen three weeks after the first onset of symptoms there was a fracture of the mid-shaft of the bone with callus formation (Fig 1). Ten weeks later after immobilisation in plaster the fracture was united (Fig 2). Final consolidation was evident after fourteen months (Fig 3).

long axis of the bone, whereas in the tibia, fibula, and femur the stress is applied almost along the axis of the bone. This may be the reason for a clearly defined line of fracture in the metatarsals and ulna which is not seen in the tibia, fibula, and femur. The extensive periosteal stripping is unusual but it has been noted before (Kitchin and Richmond, 1945).

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# ETIOLOGY OF PERONEAL SPASTIC FLAT FOOT

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A type of rigid flat foot which is accompanied by contraction of the peroneal muscles has long been recognised. The etiology is obscure. Correction of the deformity seems to be prevented by tension of the peroneal muscles, and there has been wide acceptance of the thesis that the deformity is caused by peroneal muscle spasm induced by painful stimuli arising from the tarsal joints. It has been assumed that these stimuli result from abnormal stresses thrown upon the tarsal joints by severe degrees of weak flat foot. The concept, therefore, has been that of a weak flat foot which originally was flexible but which was transformed later into a rigid flat foot by the development of peroneal spasm.

This theory does not explain all the features of peroneal spastic flat foot. In many cases it can be demonstrated by electromyographic studies that there is no spasm of the peroneal muscles, the peronei react in every way as do normal muscles. The apparent spasm, in reality, is an organic shortening of the muscles adaptive to long-continued deformity. If all possibility of peroneal spasm is eliminated by novocaine block of the peroneal nerve, by section of the peroneal nerve, by section of the peroneal tendons, or by anaesthesia supplemented with curare, the deformity still persists in many cases.

It is difficult to believe that peroneal spastic flat foot develops from flexible flat foot by reason of the stresses which fall upon the tarsal joints. Flexible flat foot is comparatively



FIG 1

Calcaneonavicular bar (in this case synostosis calcaneonavicularis) which is sometimes the cause of rigid flat foot



FIG 2

Lipping of the talus in rigid flat foot almost always indicates a tarsal anomaly limiting subtalar movement and thus distorting talo navicular movement

common in childhood, adolescence, and young adult life, and it is not at any time accompanied by peroneal spasm. On the other hand peroneal spastic flat foot is rare, and when it does occur it often dates back to early childhood, the foot has always been stiff. This suggests that it is a separate type of flat foot, probably congenital in origin, and rigid from the onset.

In 1921 an important contribution was made by Sloman. This was supplemented in 1927 by Badgley. Both authors observed that certain severe cases of the deformity were associated with a structural anomaly, namely fusion of the anterior process of the calcaneus to the navicular—coalescentia calcaneonavicularis, or calcaneonavicular bar (Fig 1). Little attention has been paid to these important contributions. Lapidus (1946), in his extensive report, made no reference to them, nor did the papers he reviewed include any suggestion that rigid flat foot might be due to structural anomalies of the tarsus.

In this paper we shall show that most cases of so-called peroneal spastic flat foot are due to tarsal anomalies. The calcaneonavicular bar, described by Sloman and Badgley, is

\* Paper read at the combined meeting of the American, British and Canadian Orthopaedic Associations in Quebec, June 1948

an occasional cause of the deformity. Much more frequently, however, the deformity is due to an anomaly which hitherto has been unrecognized by surgeons, though it has been recorded by anatomists, namely, *coalescentia talocalcanea* or talocalcaneal bridge. Both anomalies are occasionally present in the same foot, and it is possible that other tarsal anomalies may also lead to rigid flat foot.

#### INCIDENCE OF PERONEAL SPASTIC FLAT FOOT

Examination of 3600 Canadian males who presented themselves for enlistment in the Canadian Army showed that seventy-four had peroneal spastic flat foot—an incidence of 2 per cent. This was one-third the incidence of flexible flat foot (217 cases—6 per cent). There was one case of calcaneonavicular bar, revealed by radiographic examination (Fig. 1). It did not cause symptoms or interfere with training as a soldier. Peroneal spastic flat foot caused serious disability. It interfered with military training. In nearly all cases the lateral radiograph showed tipping of the superior margin of the head of the talus—an anomaly of particular significance which will be discussed later.

#### TARSAL ANOMALIES—THE CAUSE OF RIGID FLAT FEET

Two years ago, in developing a medial approach for the treatment of peroneal spastic flat foot by subtalar and talonavicular fusion, we noted a bridge of bone springing from the



FIG 3

Radiographic projection necessary to reveal talocalcaneal bridge. The central X-ray beam is projected downwards and forwards at an angle of 45 degrees through the heels which have been freed of the leg shadow by flexing the knees.

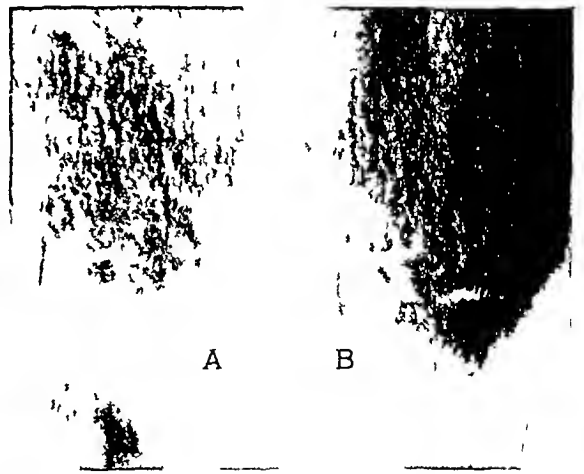


FIG 4

Radiograph obtained by the technique depicted in Fig. 3 in a patient who had a talocalcaneal bridge on the left side (A). On the right side (B) which is normal the joint between the sustentaculum tali and the neck of the talus can be seen.

medial surface of the talus, spanning the subtalar joint, and meeting a mass of bone from the medial surface of the calcaneus at the posterior end of the sustentaculum tali. Since then we have found this abnormality in twelve of the seventeen cases of peroneal spastic flat foot which have come under our care. The remaining five cases included three with calcaneonavicular bars and two of tarsal rheumatoid arthritis. In this small series, therefore, tarsal anomalies were the cause of deformity in 88 per cent of cases; in more than two-thirds of the cases there was a talocalcaneal bridge, and in nearly one-fifth there was a calcaneonavicular bar.

**Radiographic demonstration of talocalcaneal bridge**—Failure to recognise this anomaly, and to associate it with peroneal spastic flat foot, must be attributed to the difficulties of radiographic visualisation. It is not seen in ordinary projections of the foot, a special projection is necessary if clear pictures are to be secured (Figs. 3 and 4).



In a normal foot this projection passes between the sustentaculum and neck of the talus so that the joint space is shown clearly, when there is talocalcaneal fusion the joint space is replaced by a bone bridge. A secondary change is seen in lateral radiographs, namely marginal lipping of the talonavicular joint on its dorsal surface (Fig 2). This is present

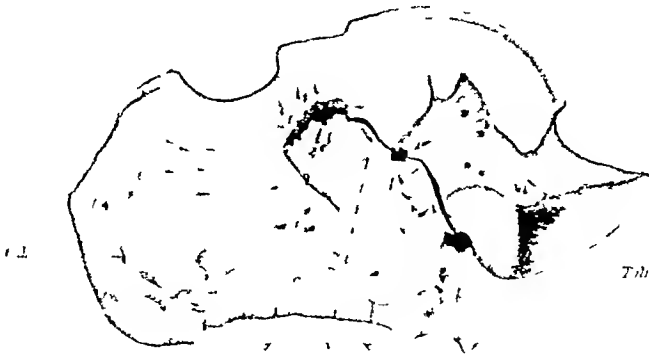


FIG 5

Reproduction of Pfitzner's illustration of his case of talocalcaneal bridge which he described thus: 'Coalescentia talocalcanea. Talus and Calcaneus in situ medial view. x—opening of the anterior arm of the canalis tarsi (the posterior arm not visible in this view opens behind the syndesmosis). y—accessory joint between talus and sustentaculum. z—syndesmosis (coalescentia) between talus and posterior end of sustentaculum.'

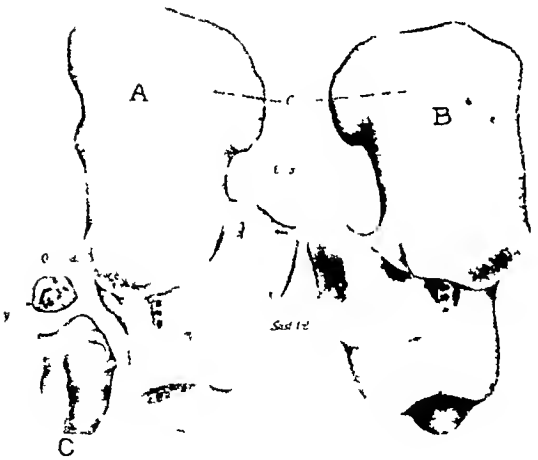


FIG 6

Pfitzner's illustration described thus: 'Os sustentaculi proprium separate on the right side (A), fused with the sustentaculum on the left (B), dorsal view (C) sustentaculum and os sustentaculi to demonstrate the contact surface—X and Y.'

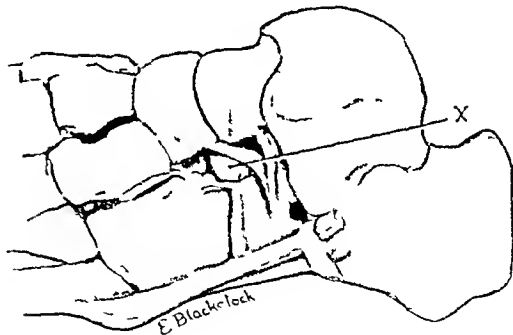


FIG 7

Specimen of the rare accessory tarsal bone, calcaneus secundarius (marked X), which is the basis of calcaneonavicular bar. (From the anatomical museum of the University of Toronto by courtesy of Professor J. C. B. Grant.)

to some degree even in children (Fig 9). With advancing years the lipping becomes still more marked (Fig 13). Such lipping on the dorsal margin of the talonavicular joint in a case of peroneal spastic flat foot is invariably associated with anomalies of the tarsal structure which limit movement of the subtalar joint—either a calcaneonavicular bar or, more commonly, a talocalcaneal bridge. The anchoring effect of these bone fusions deranges

the normal inversion-eversion movement of the subtalar and midtarsal joints and throws abnormal stresses upon the talonavicular joint, thus causing impingement of the articular margins and the development of osteophytes

**Descriptions of the talocalcaneal bridge by anatomists**—Anatomists have been aware of this talocalcaneal bridge. The best account we have found is in Pfitzner's *Beitrag zur Kenntniss des Menschlichen Extremitatenskeletts* in *Die Variationen in Aufbau des Fusskelets*, published fifty years ago. He reported two cases and added seven others from the literature. He noted variations including an accessory joint between the sustentaculum and talus (articulatio talocalcanea accessoria) a fibrous bond between the two bony masses (coalescentia talocalcanea) and bone fusion (synostosis talocalcanea). In several cases there was also synostosis calcaneonavicularis (calcaneonavicular bar). This combination existed in one of our cases. Pfitzner relates the anomaly to the accessory tarsal bone—os sustentaculi,

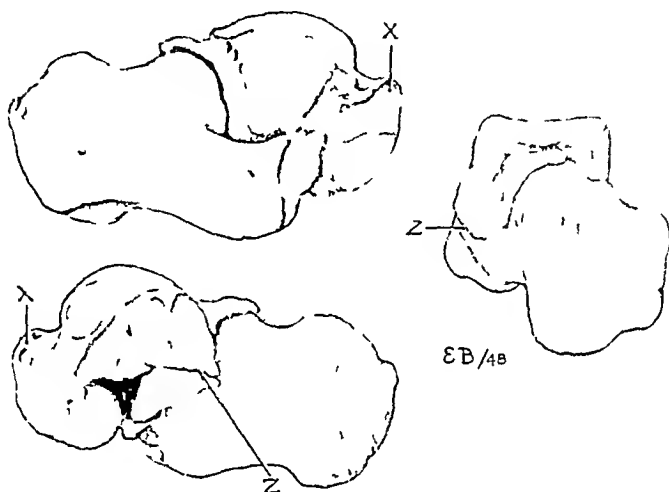


FIG 8

Specimen of right talocalcaneal bridge (from the anatomical museum of the University of Toronto by courtesy of Professor J. C. B. Grant). It is exactly similar to the specimen illustrated by Pfitzner. Below—medial view showing syndesmosis between talus and posterior end of sustentaculum (Z) and flapping of the superior margin of the articular surface of the head of the talus characteristic of rigid flat foot due to tarsal anomalies (X). To the right—posterior view showing marked valgus tilt of the calcaneus.

occasionally found at the posterior end of the sustentaculum tali. Certainly this is the position of the mass of bone which spans the subtalar joint and fuses with the body of the talus. Pfitzner's illustration of one case of talocalcaneal bridge is reproduced in Fig 5. Through the courtesy of Professor J. C. B. Grant we have been able to identify a similar case in the anatomical museum of the University of Toronto which is illustrated in Fig 8.

Dwight (1907), from a study of the Harvard anatomical material, mentioned the occurrence of coalescentia talocalcanea. He quoted Pfitzner's observations and commented on page 17 of his monograph: "The first of these exceptional bones, the os sustentaculi, forming the hind end of the sustentaculum, is very uncommon. I have never seen it separate. It is of no practical importance *except as concerned in fusion of the astragalus and os calcis* and would be hard to show in an X-ray." On page 22 we may read: "Fusion of the astragalus and os calcis occurs at the posterior end of the sustentaculum and may be attributed to the os sustentaculi fusing with both bones. The bones may be firmly



FIG 9



FIG 10

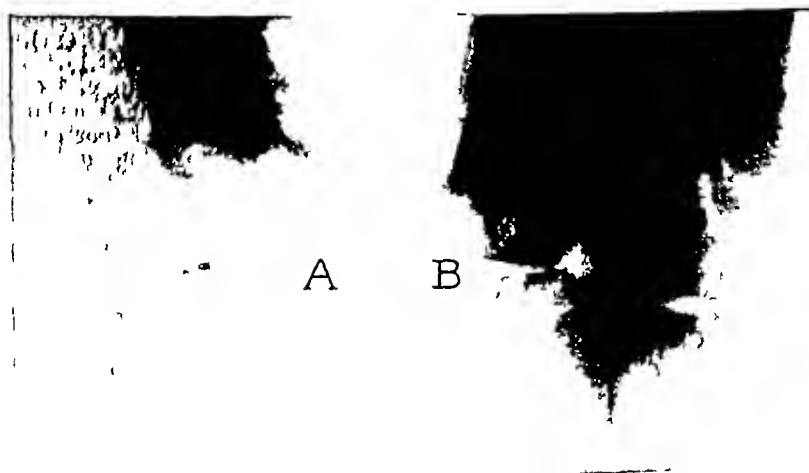


FIG 11

Osteoarthritic lipping in a thirteen-year-old child demonstrating that structural changes due to rigid flat foot from tarsal anomalies may appear early in life. Fig 9 shows a lateral projection of the involved left foot the lipping of the head of the talus being marked X. Fig 10 shows the normal right foot. Fig 11 is the postero-superior oblique projection showing the talocalcaneal bridge on the left side (A) in contrast with the normal talosustentacular joint on the right side (B).

co-ossified or they may be united by gristle, the opposed surfaces showing the characteristic irregular finish. Either of these conditions is decidedly uncommon.

**Nomenclature**—A few words regarding nomenclature are necessary. Pfitzner's strict adherence to B.N.A. usage is precise and valuable. If the bone bridge is complete it is designated—*synostosis talocalcanea*. If the bridge is interrupted it is designated—*coalescentia talocalcanea*, this term may be further modified by the terms *syndesmosis* or *synchondrosis* to designate the type of tissue which fills the gap. There is need, however, for a simple all-inclusive title and we propose the term "talocalcaneal bridge." Similar words are used to describe fusion of the calcaneus and navicular, namely, *synostosis calcaneonavicularis* and *coalescentia calcaneonavicularis*. The all-inclusive term is "calcaneonavicular bar."

### TYPES OF PERONEAL SPASTIC AND RIGID FLAT FOOT

The term peroneal spastic flat foot is often applied indiscriminately and inaccurately to certain rigid flat feet which arise from quite different causes. There are at least three such entities and there may be others. Two are related to each other, since in each there is anomaly of tarsal structure with fusion of the calcaneus to the navicular, or to the talus. In these cases there is a deformed rigid foot without peroneal spasm; the peroneal muscles are shortened adaptively in consequence of valgus deformity. The third entity is inflammatory arthritis of the tarsal joints with reflex peroneal muscle spasm which twists the foot into valgus. In the early stages this may fairly be called peroneal spastic flat foot, though it would be more informative to emphasize the nature of the pathological process which gives rise to the spasm rather than the mechanism whereby deformity is produced. The term peroneal spastic flat foot should be abandoned in favour of more precisely descriptive designations of the different varieties of the deformity. For that purpose, a detailed description of the clinical picture of the three different types is necessary.

**1) Rigid flat foot due to talocalcaneal bridge** (*Synostosis talocalcanea* or *coalescentia talocalcanea*)—In this tarsal anomaly there is fusion of the accessory os sustentaculi to the talus and calcaneus. The complete form is represented by a bone bridge arising from the calcaneus immediately behind the sustentaculum, spanning the subtalar joint and fusing with the body of the talus (*synostosis talocalcanea*). The bone bridge is not always complete, in which case there may be a fibrous bond between the calcaneus and talus (*syndesmosis talocalcanea*) or a cartilaginous bond (*synchondrosis talocalcanea*). The bridge may be a *synostosis* in one area, and a *syndesmosis* or *synchondrosis* in another, or the two masses may establish contact by means of an accessory joint (*articulatio talocalcanea accessoria*). In every variation of the anomaly, except the last, there is some fixation of the talus to the calcaneus, it is complete if *synostosis* is present, and nearly complete if the lesion is a *syndesmosis* or *synchondrosis*. This complete or incomplete fixation of the talus to the calcaneus interferes with normal freedom of inversion-eversion movement, and movements of the talonavicular joint are distorted. In consequence there is impingement of the articular margins of the talus and navicular, and very characteristic osteoarthritic lipping develops on the supero-lateral margin of the head of the talus (Fig. 8).

For reasons which are obscure, the talocalcaneal bridge forces the calcaneus into valgus and often produces marked deformity. Commonly the deformity is limited to a valgus tilt of the heel without depression of the longitudinal arch, but severe deformities combine valgus at the midtarsal joint with valgus of the heel. Our impression is that the most severe deformities are associated with *synostosis* rather than *coalescentia talocalcanea*. There may be no parallel between deformity and symptoms. Patients who have *synostosis* may have surprisingly few symptoms even when deformity is great.

Since the basis of this rigid flat foot is a congenital tarsal anomaly it is first observed in early life. It may well be present from birth, but it is seldom detected until the child begins to walk. In such cases the diagnosis of congenital club foot of the calcaneovalgus type is often made. The true lesion is not revealed in routine radiographic projections but it can be visualised by special projections (Figs 3 and 4).

**2) Rigid flat foot due to calcaneonavicular bar** (synostosis or coalescentia calcaneonavicularis)—This type of flat foot is due to fusion of the anterior process of the calcaneus to the navicular (Fig 16). The fusion may be a complete bone bridge (synostosis) or there may be a dense fibrous band (coalescentia). The anomaly is believed to result when the rare accessory tarsal bone, calcaneus secundarius, fuses to the calcaneus and the navicular. When bone fusion is not complete it is often possible to recognise that the calcaneus secundarius has fused to the calcaneus or sometimes to the navicular.



FIG 12

Feet of the patient whose radiographs are reproduced in Figs 13-15

A calcaneonavicular bar, by fixing the calcaneus to the navicular, restricts and distorts inversion-eversion movements. The foot is rigid, and abnormal stresses are thrown on the midtarsal joint. The clinical picture varies greatly. Unlike the talocalcaneal bridge, which probably always causes deformity and disablement, the calcaneonavicular bar may cause no deformity and no disability. This is particularly true when there is fusion by bone. The one instance of calcaneonavicular bar found in the Canadian Army Foot Survey was such an example: there was no deformity and no disablement, nor did it interfere with military training.

When there are symptoms, they may be grouped into well-defined syndromes. 1) There may be long standing deformity and disablement dating back to early childhood. The deformity is severe and it is associated with persistent pain and weakness, thus resembling cases of talocalcaneal bridge. This is the type of case which was described by Sloman and Badgley. 2) There may be no deformity and no disability until the

patient sustains a severe wrenching injury which gives rise to persistent pain and weakness. Such cases are due to avulsion of the calcaneus from the navicular at the fibrous bond. During the acute phase there may be peroneal spasm with rigidity of the foot. The peroneal spasm and the fixation subside rapidly with rest but they may recur if early exercise is permitted. The symptoms tend to persist. 3) There is some evidence to suggest that the calcaneonavicular bar may be fractured and even that such fractures may unite.

**3) Arthritic flat foot with peroneal spasm**—When rheumatoid arthritis affects the tarsal joints it induces peroneal spasm with resulting valgus deformity. In the later stages there is permanent damage of the joints with fixation in the deformed position. A clear distinction should be drawn between these cases and those with tarsal anomalies. This group of foot deformities must be recognised as part of the problem of arthritis. It would be desirable to recognise their true nature and use the accurate designation "arthritic flat foot with peroneal spasm."

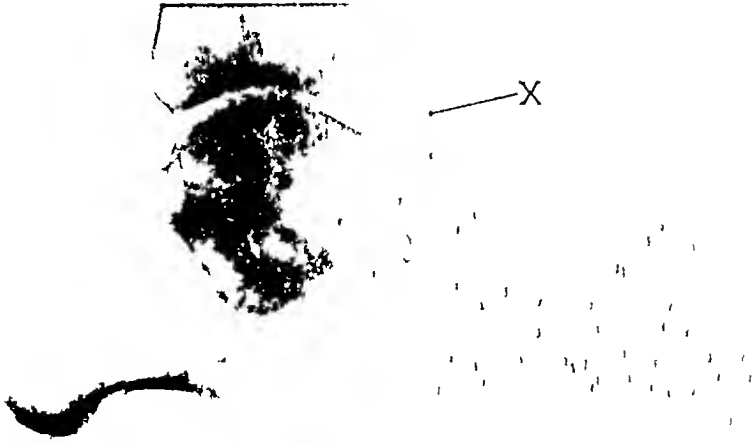


FIG 13



FIG 14



FIG 15

A twenty-six-year-old woman who had a left rigid flat foot from infancy with marked valgus of the heel (Fig 12) but without great flattening of the longitudinal arch. Fig 13 is a lateral projection of the involved left foot showing severe tipping of the talonavicular joint. Fig 14 shows the normal right foot. In Fig 15 the postero-superior oblique projection shows a talocalcaneal bridge on the left side (A) and a normal talosustentacular joint on the right side (B).



FIG 16



FIG 16A



FIG 17



FIG 17A

An example of calcaneonavicular bar, complete on the right side (Fig 16—synostosis calcaneonavicularis) and incomplete on the left side (Fig 17—syndesmosis calcaneonavicularis). The patient was a fifteen-year-old boy with moderately severe deformity and increasing disabling symptoms worse on the left side than on the right. In each foot the postero-superior oblique radiograph (on the right) shows a normal talosustentacular joint with no talocalcaneal bridge.



FIG 18

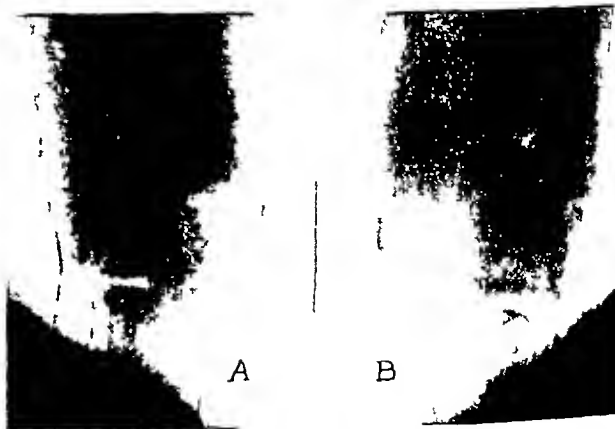


FIG 19

Severe congenital calcaneovalgus deformity of the left foot (Fig 18) treated for twelve years by manipulations and plasters. Postero-superior oblique radiographs of the feet (Fig 19) show a talocalcaneal bridge in the left foot (A) and a normal talosustentacular joint in the right foot (B). The bridge was demonstrated at operation, the deformity was corrected and the subtalar and talonavicular joints fused.

**Congenital calcaneovalgus**—The conception that most cases which are described as peroneal spastic flat foot are due to congenital anomalies of tarsal structure has led us to recognise that some, and perhaps all, cases of congenital calcaneovalgus are in reality severe examples of deformity due to a talocalcaneal bridge, sufficiently conspicuous to be recognised at birth, and totally unrelated to congenital talipes equinovarus. Review of one of our cases in the light of newly acquired knowledge revealed synostosis talocalcanea by radiography (Figs 18 and 19) and this was confirmed at operation. Badgley records a similar case due to a calcaneonavicular bar. We are inclined to believe that tarsal anomalies may prove to be the cause of most cases of congenital calcaneovalgus.

#### TREATMENT OF PERONEAL SPASTIC FLAT FOOT

**Treatment of cases with tarsal arthritis**—In general discussion of treatment, arthritic cases must be separated from tarsal anomalies. Treatment in the arthritic case must be directed to the systemic disease of which the foot problem is a local manifestation. Systemic treatment of the disease can be supplemented by local measures to correct or prevent deformity, and to protect the foot from further damage. Treatment of these cases is largely a medical problem but certain orthopaedic procedures can be valuable adjuncts. Of these the most important are manipulation under anaesthesia to correct deformity, plaster casts to maintain correction, and foot supports of the Whitman type.

**Treatment of rigid flat foot with tarsal anomalies**—Rigid flat feet due to tarsal anomalies require entirely different treatment. Generally speaking, the deformity and disablement will not be corrected except by surgical measures. We are not impressed by the operation of removing the talocalcaneal bridge, or dividing the calcaneonavicular bar, in an effort to restore normal mobility. Better correction of deformity and better function is obtained by fusion of the subtalar and talonavicular joints, and this is the procedure we advocate when the disability is severe.

**Treatment in childhood**—Arthrodesis of the tarsal joints should not be undertaken in early childhood. If possible it should be postponed until late adolescence. Some plan of management must therefore be established which will tide the patient through childhood. Repeated manipulations under anaesthesia with immobilisation in the corrected position in plaster give the best results. When deformity is less severe, much can be done by consistent support of the foot with Whitman plates.

**Operative treatment**—The only surgical procedure we have found to be of value is arthrodesis of the subtalar and talonavicular joints. This is best accomplished through a medial approach which gives direct access to the talocalcaneal bridge and to the calcaneonavicular bar when one is present. The synostosis must be removed in order to free the calcaneus from the talus. Correction of the deformity is then accomplished by remodelling the opposed surfaces of the talus and calcaneus at the subtalar joint. If deformity is severe it may be necessary to make a separate lateral incision through which to lengthen the peroneal tendons and even the peroneus brevis and outer slips of the extensor digitorum brevis. The tubercle of the navicular is removed, and the navicular and head of the talus are denuded of cartilage. Cancellous bone is packed into the field of operation and when deformity has been corrected the wound is closed and plaster is applied.

#### SUMMARY

- 1 Peroneal spastic flat foot is a term loosely and often inaccurately used to describe rigid valgus feet developing from widely different causes.
- 2 The most common causes are two anomalies of the bones of the tarsus—the calcaneonavicular bar, and the talocalcaneal bridge. The first was described in 1921 by Sloman and in 1927 by Badgley, the other is described for the first time in this paper as an etiological



factor in rigid flat foot though it has been recognised by anatomists for fifty years as a skeletal variation. The term peroneal spastic flat foot, as applied to these cases, is inaccurate since there is no spasm of the peroneal muscles. The deformity is a fixed structural deformity due to anomalous bone structure, and the apparent spasm of peroneal muscles is in reality an adaptive shortening. A better term would be rigid flat foot due to talocalcaneal bridge or calcaneonavicular bar.

3 The smaller group of patients who suffer from inflammatory lesions of the tarsal joints, chiefly due to rheumatoid arthritis, do in fact develop valgus deformity from peroneal spasm. The resemblance between the two groups is superficial and it is limited to the apparent similarity of the deformity. Though it might be justifiable to designate this type as peroneal spastic flat foot, it would be better to use the more accurate title—arthritic flat foot with peroneal spasm.

4 Lipping of the upper margin of the talonavicular joint strongly suggests the existence of one or other of the *congenital* anomalies. Both anomalies are visualised only by special radiological projections.

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# DENERVATION OF THE ELBOW JOINT FOR THE RELIEF OF PAIN

## A Preliminary Report

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Few accurate studies have been made of the pain patterns and pathways of articular structures. In the synovial membrane there is a fine plexus of delicate nerve fibrils with end-bulbs just beneath the free surface. Intra-articular sensation is recorded through this network, and impulses reach the neighbouring main nerve trunks along small branches. In addition to this purely sensory articular mechanism, there is an important auxiliary sensory defence, designated as "deep" sensation which has to do chiefly with recognition of movement and appreciation of position, but which includes also some pain appreciation. Adjacent muscles serve as accessory ligaments and derive their nerve supply from the same sources as the articular structures. Nerve fibrils filter into juxta-articular ligamentous attachments along vascular channels and reinforce both superficial and deep pathways.

Impulses arising from all these sources undergo regrouping in their passage to the central nervous system. Impulses from both deep and superficial origins which are capable of provoking pain are screened by specific receptors associated with the secondary tracts. This leads to a grouping and gathering together of pain stimuli which then pass up the spinal cord in a separate tract. The same mechanism applies to thermal and tactile appreciation. In this anatomical pattern lies the explanation for the profound changes in joints which may occur in disease of the posterior columns. Obliteration of appreciation of all protecting impulses exposes joints to continued and uncontrolled injury. On the other hand, when the "superficial" system is involved alone, as in the case of division of a peripheral nerve, there remains a line of protection in the deep system. Loss of deep sensibility, and appreciation of joint position and vibration is prominent in tabes dorsalis, whereas appreciation of deep pressure and joint movement is characteristic of peripheral nerve injury. In supervising a group of more than one thousand peripheral nerve injuries, the author did not see one example of the characteristic ablative arthropathy of tabes and syringomyelia.

Surgical measures adopted for the relief of pain from articular structures have included operations on the spinal cord and sympathetic system as well as on peripheral nerves. Tractotomy is a formidable procedure which is not always controlled accurately, the results are uncertain, and the complications may be serious. Attacks on the sympathetic system do not reach the seat of the disturbance. Complete section of peripheral nerve trunks, producing motor and sensory loss, leads to complications such as trophic changes which are even more serious than the disturbance for which the operation is done. It is apparent from these considerations that neurosurgical efforts to relieve joint pain are best directed to the peripheral or articular mechanism. This involves understanding of the physiological limitations of such procedures, and accurate knowledge of the peripheral neuro-anatomy.

## INNERVATION OF THE ELBOW JOINT

In studying a group of nerve injuries the author has had the opportunity of making observations on the pattern of innervation of certain joints. Study of the innervation of 152 elbow joints from the ulnar, median, radial, and musculocutaneous nerves, is summarised

\* *From a Paper read at the Joint Meeting of the American, British and Canadian Orthopaedic Associations in Quebec, June 1948.*

in Table I The largest and most constant contribution comes from ulnar nerve, as a rule there is a single stout articular twig, often two twigs can be identified, occasionally there are several The median contribution is not nearly so constant, or so large, as that of the ulnar nerve and it shows some degree of reciprocity with the ulnar supply When there is a small single ulnar twig there is likely to be a large median contribution, where there are multiple ulnar twigs the median supply is meagre The musculo-cutaneous nerve, while it is in the process of extending to more superficial structures, occasionally sends a stout branch directly down into the joint, and frequently many fine twigs pass to the perarticular structures The radial nerve at the front of the joint seldom contributes a good branch, but as it becomes associated with the radial and interosseous arteries, nerve twigs accompany branches of the vessels to the region of the radio-ulnar joint On the posterior aspect, the branch from the radial nerve to the anconaeus muscle terminates in a small plexus in or beneath the muscle, mingling with a group of small vessels This network lies directly over

TABLE I

Nerve	Number of operations	No branches	One branch	Two or more branches
Ulnar	58	2	42	14
Median	28	17	10	1
Radial	32	28	4	0
Musculocutaneous	18	14	4	0
Anconaeus branch	16		Constant twigs	

the radio-ulnar joint, and twigs pass from the plexus to the joint This contribution shows much variability Sometimes nerve filaments cannot be traced through the anconaeus, but they have been seen often enough to make it desirable to expose this area in attempting denervation of the elbow joint

Branches from the main nerve trunks to the elbow joint follow a constant pattern Articular twigs are supplied before muscular branches In stripping nerves across the joint, when motor branches are once reached it is unlikely that further branches to the joint will be found

#### APPLICATION OF NEURECTOMY TO THE ELBOW JOINT

There is much interest in peripheral articular denervation as applied to the elbow joint which is easily exposed and is a non-weight-bearing joint In cases of post-traumatic arthritis, and osteoarthritis, the operation seems reasonable as an alternative to arthrodesis or arthroplasty In a young labouring man, with extensive articular damage, arthrodesis may be the procedure of choice Nevertheless, many patients are reluctant to accept stiffness of the elbow and are eager to cling to mobility, no matter how small the range Arthroplasty is also a possibility, but it may leave an unstable limb which is unsuitable for heavy work Furthermore, in older patients, less extensive operative procedures are preferable, it is relief of pain which is paramount and rugged use is less essential

**Technique of operation**—The joint is approached through three incisions The first is along the border of the biceps, mid-way between the tendon and the medial epicondyle Through this incision both median and ulnar nerves are exposed The branches are identified about two inches above the joint and are traced to the elbow It is often advisable to transplant the ulnar nerve from the groove behind the medial epicondyle to the front of the joint, particularly when there is valgus deformity with symptoms of ulnar neuritis There may be one, two, or three articular branches, each is severed Branches from the median nerve are

also cut. The trunks are stripped from their moorings well above and well below the joint so that all filamentous twigs, as well as definite branches, are divided.

An incision of similar length is made on the lateral side of the joint mid-way between the biceps tendon and the lateral epicondyle. In the interval between the biceps and brachioradialis muscles the musculocutaneous nerve will be found. This is stripped across the joint and articular twigs are crushed with mosquito forceps. As the nerve branches are exposed they are pinched gently; if there is a motor response they are spared; if not, they are divided. Deeper in this interval the radial nerve can be identified. It is traced well down towards the bifurcation, and any branches which are found extending to articular structures in company with small arteries are severed.

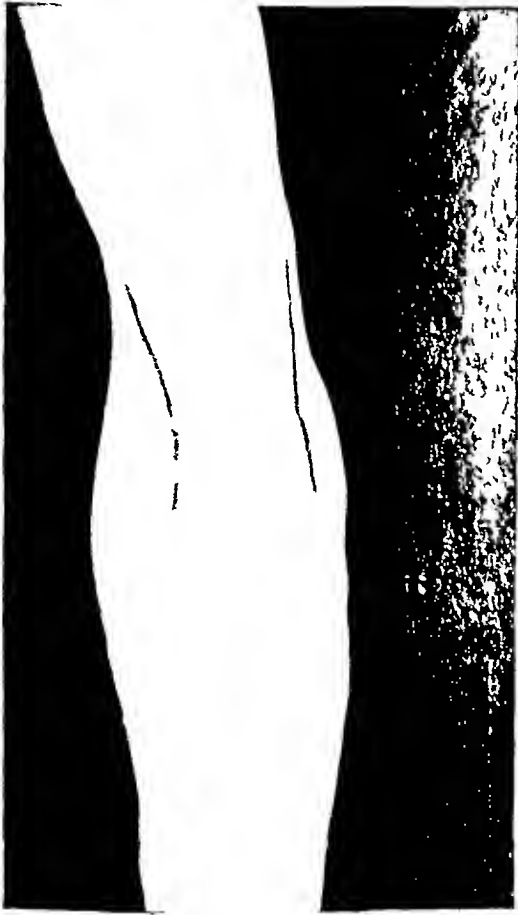


FIG 1

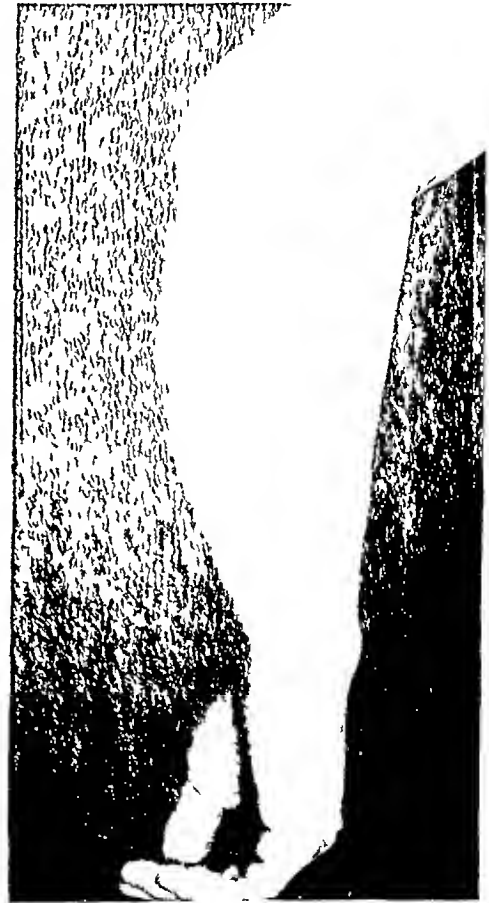


FIG 2

Fig 1 shows the incisions used for approach to the ulnar, median, radial and musculocutaneous branches. Fig 2 shows the incision used for exposure of the branches to the anconeus.

The operation is completed by a small incision over the anconeus muscle, just behind the lateral epicondyle. The nerve filaments, accompanied by a small vascular plexus, are identified running at right angles to the muscle fibres. As a rule, the whole neurovascular bundle is cut. Sometimes the under surface of the anconeus is stripped with scissors so that fine, penetrating twigs are severed from the subjacent capsule.

Throughout the procedure emphasis must be placed on the stripping of nerves, rather than on tedious search for individual articular branches. The anatomical law that articular branches are supplied first, and motor branches only after that, is dependable. No damage



FIG 3  
Case 1  
Gunshot wound of elbow



FIG 4  
Case 2  
Osteomyelitis lower end humerus



FIG 5  
Case 3  
Gunshot wound of elbow

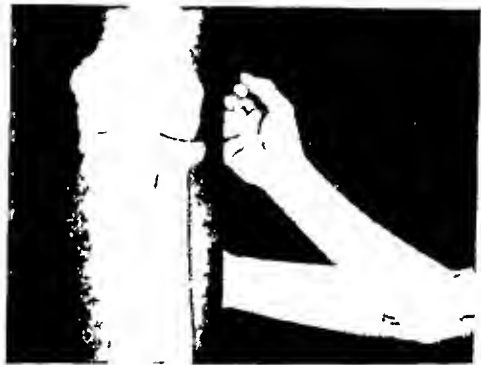


FIG 6  
Case 4  
Monteggia fracture of forearm



FIG 7  
Case 5  
Compound fracture humerus

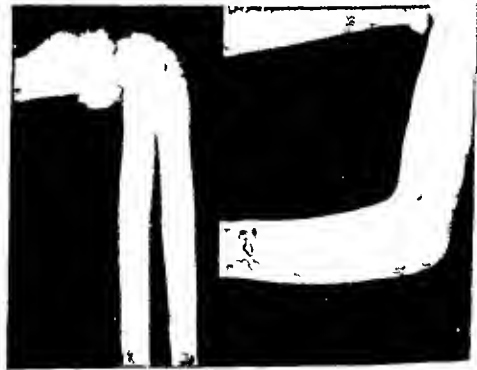


FIG 8  
Case 6  
Gunshot wound of elbow

FIGS 3-13

Cases of elbow injury for which denervation of the joint has been used for the relief of pain

is done by "stripping" Furthermore, the most proximal muscle supplied by a main nerve trunk has often a dual or triple innervation so that even the first motor branch may be sacrificed without significant damage



FIG 9  
Case 7  
G S W elbow

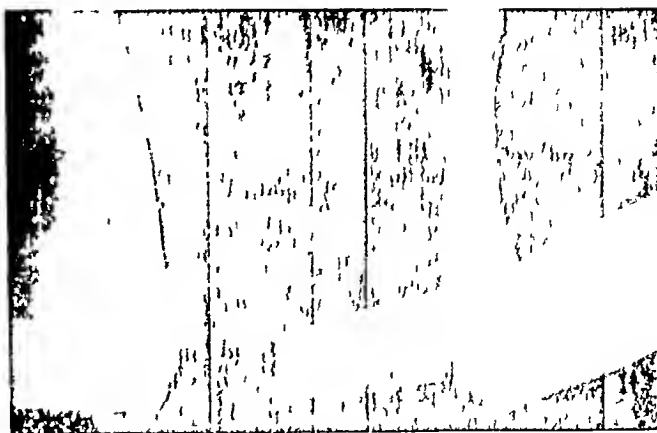


FIG 10  
Case 8  
Rheumatoid Arthritis of elbow



FIG 11  
Case 9  
G S W elbow



FIG 12  
Case 10  
G S W elbow



FIG 13  
Case 11  
Compound fracture

### RESULTS OF DENERVATION OF THE ELBOW JOINT

This operation has been carried out in eleven patients who were available for follow-up study. In each case the patient complained before operation of pain in the elbow, aggravated by activity, and persisting at night even to the point of interfering with sleep. Radiographic examination showed varying degrees of post-traumatic osteoarthritis.

The longest period of post-operative observation has been twenty-one months, and the shortest period four months. The results of denervation have been similar in all cases. Immediately after operation, upon recovery from the anaesthetic, there was a changed sensation in the elbow. There was sometimes pain in the region of the incisions but the dragging and aching sensation had disappeared. When the wounds were healed, sharp and stabbing pain on movement was no longer experienced. The patients were able to sleep undisturbed. Upon resuming activity, carrying the arm at the side was no longer painful, and whatever the previous range of movement may have been, it was regained without

TABLE II

Case No Name	History and duration of symptoms	Age	X-ray changes	Diagnosis	Length of time since operation	Result and rehabilitation
1 A F (Fig 3)	G S W elbow, 1944 pain and limitation of movement, 3 years	29	Marked	Post-traumatic osteoarthritis	21 months	Relief of pain through retained range of move- ment Returned to moderately strenuous manual activity involv- ing continued use of right arm
2 J C (Fig 4)	G S W elbow, 1944 osteomyelitis lower end of humerus pain and limitation of movement 18 months	38	Marked	Osteomyelitis of humerus Post- traumatic arthritis	21 months	Complete relief of pain through retained range of movement Returned to his occupation as a polisher
3 W B (Fig 5)	G S W elbow 1944 osteomyelitis and mal-union of humerus effusion of left elbow 6 months	29	Minimal	G S W elbow Osteomyelitis humerus	9 months	Freedom of pain through 90 degrees of movement Returned to former occupation
4 F J S (Fig 6)	Old Monteggia fracture of forearm increasing pain and stiffness in elbow 2 years	54	Minimal	Old fracture ulna Osteoarthritis of elbow Incomplete delayed ulnar palsy	7 months	Relief of pain through retained range Improve- ment but not complete recovery of ulnar paresis Returned to previous occupation which did not involve heavy work
5 C W F (Fig 7)	G S W elbow com- pound fracture of humerus 2 years	32	Marked	Post-traumatic osteoarthritis left elbow	7 months	Freedom of pain through retained range Returned to occupation not involving strenuous use of left arm
6 A A (Fig 8)	G S W elbow 1917 working as fireman until 6 months ago when persistent pain seriously limited activities	54	Marked	G S W elbow Post-traumatic osteoarthritis	17 months	Immediate relief of pain through previous range of movement Pain at extremes of flexion and extension Residual tenderness over ulnar nerve Returned to former occupation
7 W A G (Fig 9)	G S W compound fracture of right humerus Recurrent osteomyelitis, 2 years	56	Minimal	G S W humerus Recurrent osteo- myelitis of humerus	7 months	Improvement, but not complete relief of aching pain previously present in elbow Returned to former occupation as a painter
8 D H (Fig 10)	Recurrent attacks of pain swelling and limitation of movement in both elbows left worse than right, 5 years	53	Marked	Rheumatoid arthritis	13 months	Complete relief of pain and increased movement for 6 months Symptoms returned after 8 months necessitating arthrodesis Returned to heavy work as millwright
9 R E F (Fig 11)	G S W elbow 1944, 6 months	24	Marked	Post-traumatic osteoarthritis of elbow Ulnar nerve paralysis	4 months	Relief of pain through limited range of move- ment Returned to clerical occupation
10 W R H (Fig 12)	G S W elbow, 1942, 3 years	27	Minimal	Post-traumatic osteoarthritis of elbow	4 months	Relief of pain through range of movement Discarded electric pad worn continuously at night Returned to clerical work
11 M T (Fig 13)	Old compound fracture of elbow, persistent pain after recent fall	39	Marked	Post-traumatic osteoarthritis of elbow	6 months	Relief of pain except at extremes of range Returned to duty as a nurse

discomfort. Forced movement, particularly at the limit of the range, caused discomfort which was not the same as before and was described as "stiffness" but without acute pain. In cases where there was limitation of movement by a bone block, passive manipulation caused discomfort at the limits of flexion and extension movements, but no such discomfort accompanied active and controlled use of the limb. In all cases but one, improvement was maintained and the patients went back to their former occupations. The exception was a man who for six months gained sufficient relief to return to work as a machinist. But then came back with a painful, swollen, and inflamed joint. There were similar symptoms in the opposite elbow. Sections of synovium taken at the time of arthrodesis demonstrated an acute, almost pyogenic-like, reaction, and the diagnosis of rheumatoid arthritis has been established (Case 8).

### CONCLUSIONS

1. A method of denervating the elbow joint, based upon observations on the articular branches of the main nerve trunks, is presented.
2. In a small group of cases with post-traumatic arthritis and osteoarthritis, relief of pain and restoration of painless movement has been gained.
3. There was recurrence of pain after six months in one patient with acute rheumatoid arthritis, in such cases denervation is not recommended until further study is completed.
4. Denervation must be as complete as possible and full exposure with stripping of nerve trunks is recommended. There have been no complications.
5. The results in this small series of cases are encouraging, but patients should be warned that there will be no significant increase in the range of movement, and that a normal joint is not to be expected.
6. Articular neurectomy is still on trial. If the limitations are recognised, the procedure may have a useful place in the relief of pain in the elbow joint.

### DISCUSSION

**Dr J. Albert Key** (St. Louis, Missouri): I was interested in reading Dr Bateman's paper and a little apprehensive about trying his operation. Now that I have seen his movie and noted the ease with which these nerves are picked up by him, I think that some day I may try it provided that I get a suitable case. But I do not recall having seen a case in which I would advise it. Pain is not a prominent feature in traumatic or hypertrophic arthritis of the elbow joint and it can usually be relieved by a simple operation such as resection of the head of the radius. There may be a field for this procedure of denervation in rheumatoid arthritis but I would need to know more about the end-results before advising it. Do the nerves regenerate, and is there then recurrence of pain? Are we going to have neurotrophic joints? Over a good many years I have performed obturator neurectomy in an effort to relieve pain in the hip. That operation removes only part of the nerve supply of the hip joint, and there have been no neurotrophic disturbances but I believe that if you take all the nerves, there may be a possibility of neurotrophic joints resulting. I hope that we may have another report within a few years showing whether or not there have been trophic changes as a result of complete denervation and whether or not relief of pain has been permanent.

**Dr James E. Bateman** (Toronto, in reply): I can assure you that the danger of doing damage to the nerve trunks is small. There have been no complications from exposure and stripping of nerves across the joints, there is a good margin of safety. The possibility that neurotrophic joints may develop cannot be answered from a series so small as this and from a follow-up study of so short a duration but here again there is a wide margin of safety. The profound disturbance of sensory appreciation which occurs in posterior column disease is an entirely different entity as compared with denervation by this technique. Sensation from joints is mediated by sensory endings in the synovium but there is an important second line of protection from the juxta-articular branches which filter into the area along muscle and tendon attachments. In posterior column disease both superficial and deep sensations are obliterated in this operative denervation it is only the superficial sensation which is interrupted. I cannot finish without expressing the appreciation and indeed the thrill I have experienced in joining the swelling ranks of prominent contributors who have been subjected to the kindly and constructive criticisms of Dr Key.



# ISCHIO-FEMORAL ARTHRODESIS

H A BRITAIN, NORWICH, ENGLAND \*

Accurate diagnosis has disabused our minds of the notion that it is possible to preserve mobility of the hip joint after tuberculous infection. At present, arthrodesis is the accepted form of treatment, and for joints which have been disorganised by disease it will probably remain so, though future developments in antibiotics may change this conception.

Ischio-femoral arthrodesis offers certain advantages over the various types of ilio-femoral arthrodesis. It is not suggested that this is the only operation by which to fuse a diseased hip, but it is suggested that it may be performed with success more often than any other. Ischio-femoral fusion may not, however, be feasible in every patient with a tuberculous hip. The ischium is a more rare site for extension of disease than the ilium, but it is occasionally involved, and a graft which is placed in a tuberculous area will probably fail. The graft may be able to traverse the diseased area and find a firm seat in healthy bone at each end, thus immobilising the joint for sufficient time to allow the disease to heal, but it will probably be eaten into and sustain fracture.

Nevertheless, a graft in compression has more chance of uniting after fracture than a graft in tension, which has little or none.

It is essential, therefore, to visualise the disease and the patient as a whole, to consider the form of arthrodesis which is most likely to succeed, and to decide at what stage, and at what best time, to perform the arthrodesis. It is now my custom to outline with a pencil the area of disease shown in the X-ray, and to try to keep outside this area in the course of the operation. If an ilio-femoral arthrodesis appears to offer a better chance of healing, then I carry this out. It is to be recognised, however, that the osteotomy performed in an ischio-femoral operation confers a unique advantage on the tuberculous hip, unlike other joints, in that the disease can be short-circuited and



FIG 1

The area of old disease is outlined with a pencil and an endeavour is made to keep outside this area during the operation.

changed from the serious problem of joint disease to the less serious one of bone disease.

**Stages of the operation—1)** The patient having been placed on an orthopaedic table with his feet attached to the foot pieces and with the limbs in slight traction, two Michel clips are placed over the front of the hip joint. A calibrated guide is inserted on the antero-inferior aspect of the shaft and neck of the femur. An X-ray photograph is taken. An orthopaedic table is used so that there will be no pressure from behind which might press the sciatic nerve forwards against the neck of the femur.

**2)** While the photograph is being developed, a tibial bone graft is cut. I prefer to take it from the affected limb in order that the patient may have at least one sound limb upon which to walk when he is convalescent. It is essential to cut a wide tibial graft. The whole basis of the operation of ischio-femoral arthrodesis is the use of a wide tibial graft, which is more

\* Paper read at the combined meeting of the American, British and Canadian Orthopaedic Associations, Quebec, June 1948.



FIG 2

Theatre radiograph of clips fixed on the skin and of the calibrated guide in the bone



FIG 3

Theatre radiograph of the drill in position through the femur into the ischium



FIG 4

Theatre radiograph of the chisels in situ. There is evidence of ischial penetration at the point of the chisels



FIG 5

Theatre radiograph of the graft in situ. The outer surface of the trochanter has been fragmented; the shaft is being displaced inwards



FIG 6



FIG 7

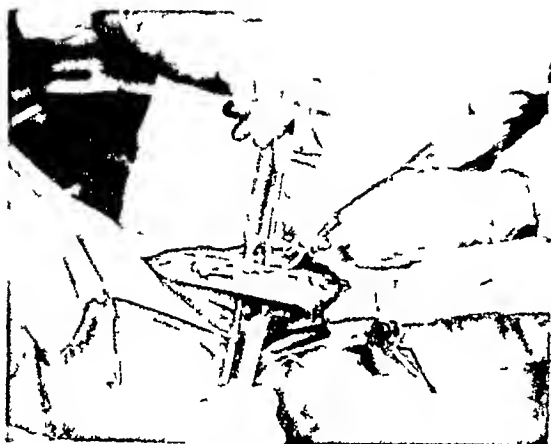


FIG 8



FIG 9



FIG 10

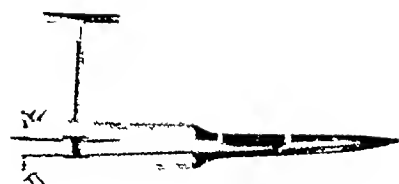


FIG 11

Fig 6 shows the patient on an orthopaedic table with cassette in position, note that there is no pressure from behind displacing the sciatic nerve forwards. In Fig 7 two Michel clips have been fixed, one over the greater trochanter and one on the middle point of the line from anterior superior iliac spine to the symphysis pubis. A cannulated guide has been passed in front and below the femoral neck. Figs 8 and 9 show the graft being cut from the whole width of the tibia including the postero-medial and postero lateral borders. One end of the graft is then cut to the shape of a chisel (Fig 10). Fig 11 shows the twin chisels one with a ridge and shoulders to receive the other, they can be separated by the screw so that the cleft in the ischium is widened, each has a round projection so that it can be tapped out with a punch.



FIG 12



FIG 13



FIG 14



FIG 15



FIG 16



FIG 17

The drill is passed through the femur into the ischium (Fig 12). When the position has been verified radiographically the osteotomy is started (Fig 13). *If the posterior limit of the chisel is in front of the posterior margin of the greater trochanter and the chisel is kept in the horizontal plane the sciatic nerve cannot be struck.* Fig 14 shows the chisels being separated by means of a special screw so that the cleft in the ischium is made wide enough to receive the graft. The male chisel is then tapped out (Fig 15). The greater trochanter is hooked up with a retractor and the graft is introduced along the female chisel (Fig 16). The graft is punched home (Fig 17).

certain to engage in bone in the ischium, though not necessarily in the tuber ischi. One may aim at a large target with a small arrow, but here one is aiming at a small target with a large bludgeon, and if any part of the bludgeon hits the target, success is probably assured. At first it is difficult to cut a graft which includes the postero-lateral and postero-medial borders of the tibia, but with practice this becomes simple. An additional advantage is that, since the width of the tibia has been decreased, the periosteum may be sutured without tension and the haematoma is enclosed, thus encouraging regeneration of the bone. After the graft has been taken it is shaped with the electric saw so that one end resembles a chisel.

3) A curved incision with the convexity passing upwards is made, starting one inch above the greater trochanter and finishing four inches distal to it. A straight incision is made down to bone through the vastus lateralis throughout the limits of the incision, and the



FIG. 18

Tuberculous hip operated on at the age of fifteen years after twenty months of disease. Radiograph eight years after operation. Note the apparent reformation of a medullary canal in the graft.

shaft of the femur is cleared. A site for osteotomy is chosen, bearing in mind that the lower limit of the greater trochanter is a point which is easy to verify, and that the Michel clips are an additional guide.

4) A small hand-drill is introduced through the femur at an angle of 45 degrees in the coronal plane, aiming at one of the Michel clips. After the inner wall of the femur has been pierced there is lack of resistance until the ischium is struck. The position of the drill is verified by an X-ray photograph.

5) A subtrochanteric osteotomy is performed. Special chisels are used with a screw to separate them, one chisel with a slot and shoulders to receive the other. After the osteotomy has been performed by one chisel (the male) it is tapped gently inwards until it engages in the ischium. An X-ray photograph is then taken, and the female chisel is introduced below the first.



FIG 19

Case illustrating the difficulty of placing the graft in the ischial bone cleft unless special chisels are used



FIG 20

Man aged fifty four years with osteoarthritis of the hip joint. Graft well placed. Radiograph six months after operation



FIG 21



FIG 22

Congenital subluxation of the hip joint with secondary arthritis in a patient aged twenty eight years. Fig 21 is the radiograph taken six months after ischio-femoral arthrodesis using a graft from the femur. Fig 22 shows the same hip joint eight years later. Note not only that the ischio femora fusion is sound, but that the hip joint is consolidated. No intra-articular operation was performed.

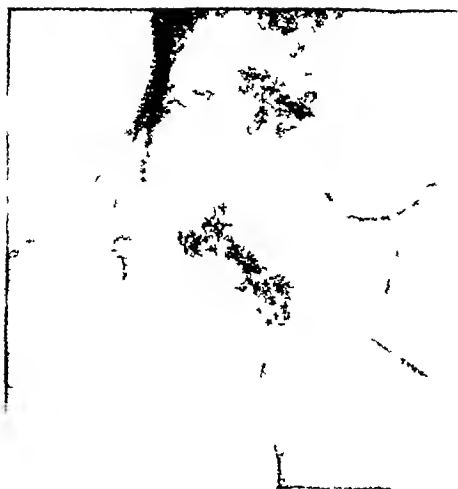


FIG 23

Tuberculosis of the left hip joint in a patient aged twenty-three years. Ischio-femoral arthrodesis was performed in 1942. Note the porosis in the upper part of the femoral head, the femoral neck, and the greater trochanter which are not now weight-bearing.



FIG 24

Tuberculous hip, patient aged fifteen years. Four operations were needed before ankylosis was sound. The lower graft failed because it passed through the obturator foramen. The upper graft has fused. Remnants of other grafts can be seen.

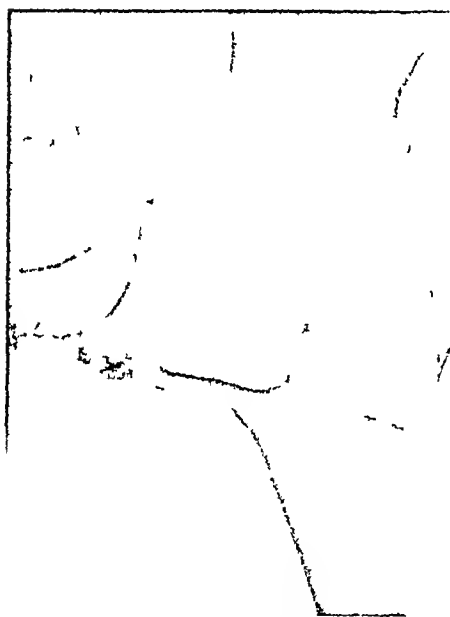


FIG 25

Boy aged seventeen years with very active tuberculous disease of the hip. The graft was deliberately placed far from the hip joint into the ischial ramus. Radiograph one year after operation shows that the disease is healing.



FIG 26

Tuberculosis of the right hip joint fused at the age of sixteen years after ten years of active disease. In this case the graft has united to the ascending pubic ramus. Radiograph nine years after operation.

6) The chisels are separated gradually by the introduction of a screw. By this means a V-shaped slot is made in the ischium, the entrance should be wider than the graft it is to receive. This overcomes one of the chief difficulties of the operation, namely, the finding of the cleft in the ischium by the graft.

7) The male chisel is then withdrawn. The greater trochanter is hooked upwards with a retractor, and the graft is tapped in along the female chisel. As it is tapped in, the female chisel is withdrawn. After the graft is felt to engage in the cleft in the ischium it is punched firmly home. *If any difficulty is met in finding the cleft, it may be felt by the finger. The*

*middle finger is inserted in front of the greater trochanter and below the neck of the femur. In our last dozen cases we have had no difficulty in feeling the cleft.*

8) The distal fragment of the femur is displaced inwards with a punch until it makes contact with the ischium, thereby supporting the middle part of the graft.

9) A double plaster spica is applied and maintained for at least four months, or until fusion occurs.

### COMPLICATIONS

It has been stressed that this operation is difficult because it is blind. For this reason there must be a clear visual conception of the anatomy. The dangers are a) striking the sciatic nerve, b) haemorrhage.

**Striking the sciatic nerve**—This should not occur. *If the posterior edge of the chisel is in front of the posterior margin of the greater trochanter, and the chisel is maintained horizontally, the sciatic nerve cannot be struck.* The nerve can be hit only if the chisel is directed posteriorly. In the course of many operations on the cadaver I have found that unless the chisel is directed at an angle of 45 degrees to 60 degrees backwards it is impossible to hit the nerve. There may perhaps be some danger when there is adduction deformity of the hip. In the flexed hip more care has to be exercised because the sciatic nerve may be on the stretch. It should be understood clearly that the area of bone at which one is aiming is not the tuber ischi but the bifurcation of the pelvic ramus below the acetabulum, consisting of the anterior ramus of the pubis and the posterior ramus of the ischium. At this level the sciatic nerve is far behind, and it cannot be struck by a chisel which is placed horizontally.

**Haemorrhage**—Some oozing always takes place, and sometimes it may appear alarming. If the anterior pelvic brim is traversed, the obturator artery may be divided. In addition one may divide branches of the lateral femoral circumflex artery taking part in the digital anastomosis, and there may be muscular oozing from dividing the iliopsoas and small muscle like the piriformis and obturators. None of this haemorrhage is serious, with the possible exception of that from the obturator artery in a debilitated patient. There is no doubt that oozing does take place and that it goes on after the operation, so that it is wise to have blood transfusions readily available. I have had no fatalities from haemorrhage, and shock is the exception rather than the rule. McMurray's statement that there is more shock after this operation than after any other method of arthrodesis is, in my experience, entirely without foundation. I would state dogmatically that if the operation is performed with correct technique there is much less shock than with any other method.

### REASONS FOR FAILURE OF FUSION

The possible causes of failure are 1) passing the chisel or graft through the obturator foramen, thus securing inadequate ischial contact, 2) non-union between the osteotomised femoral fragments, or between the graft and the femoral fragment at the outer end, 3) extension of disease into the area of the graft.

**Passing the chisel or graft through the obturator foramen**—Striking bone is, of course, of paramount importance, and it is wise to take the precaution of using a drill or guide as suggested by Freiberg (1946). I have adopted this measure during the past two years. In earlier observations I stated that the obliquity of the obturator foramen was such as to prohibit the passage of a graft through it, but this statement has had to be modified in the light of further experience. A graft directed transversely and horizontally may pass through the obturator foramen, especially in children where the tibia is not wide. Once again, a wide tibial graft is essential for this operation. If disease permits, the graft may be directed more vertically, when it is certain that bone will be struck. Extension of tuberculous disease may of course determine the position of the graft, but whenever possible the graft should approximate towards the vertical position.



*Non-union between the osteotomised femoral fragments, or between the graft and the femoral fragment at the outer end*—In three patients fibrous union occurred between the greater trochanter and the distal fragment of the femur. In two patients a second operation was performed, and union occurred after freshening these surfaces. This, of course, is a minor operation as compared with the major problem of securing fusion of the diseased hip. It is now my custom to fragment the outer surface of the greater trochanter and to place the bone chips in the site of osteotomy.

*Extension of disease into the area of the graft*—Extension of disease may be beyond the control of the surgeon. It seldom happens, but if it does the indication is for more prolonged immobilisation. Once there is no doubt that the graft has become diseased, the operation should be repeated. It is an important point that the second operation is less difficult than the first because the upper end, and the direction, of the first graft can be identified easily.

It must be emphasised that one of the essential features of the operation is that it is closed, and that its success may depend upon this. Wider exposures, which mobilise both femoral fragments in the attempt to see what one is doing, lose the advantage of fixation of the graft between the fragments and may cause non-union.

### Results of Ischio-femoral Arthrodesis

Total number of operations	105
Total number of patients	95
Successful fusions	82

Tuberculosis of the hip—38 patients, 48 operations, 32 fusions

Two patients required 4 operations, one 3 operations, and two 2 operations

Osteoarthritis of the hip—52 patients, 45 fusions

In seven cases the arthritis was secondary to congenital dislocation of the hip, one patient aged fifty-eight years died eight days after operation from pulmonary embolism confirmed by post mortem examination.

Infective arthritis of the hip—5 patients, 5 fusions

### SUMMARY

It will be seen that the proportion of successful fusions in this series of ninety-five patients treated by ischio-femoral arthrodesis of the hip was over 80 per cent. Similar percentages of successful fusion have been reported by Knight (1945), Freiberg (1946), Langston (1947), and Nisbet, who was resident surgical officer at the Robert Jones and Agnes Hunt Orthopaedic Hospital, and informed me in a personal communication that he had carried out twenty-six operations with an approximate fusion rate of 80 per cent. He stated: "It is the only operation which gives a reasonable chance of a successful arthrodesis in children. Up till now at Oswestry the chances of a fusion by the other methods in children have proved so disappointing that the operation had been abandoned. Dame Agnes Hunt, with her vast experience of the condition, was always very annoyed when she found a surgeon trying to fuse a child's hip. All this has been changed."

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# POSTERIOR DISLOCATION OF THE SHOULDER JOINT

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Dislocation of the shoulder joint with backward displacement of the humeral head is an unusual injury. The physical signs are often masked by swelling and, although careful study of antero-posterior radiographs may be suggestive, the diagnosis is often missed at the first attendance of the patient.

Wood (1941) reported three posterior dislocations in a series of 115 dislocations of the shoulder joint treated in the fracture clinics of the Massachusetts General Hospital between 1930 and 1938. Thomas (1937) reported four posterior dislocations in a series of 6000 shoulder examinations in his private practice, and he referred to three other cases. Wood found that the condition had received little attention in the text-books he studied, and such well-known books as those of Bohler (1935) and Watson-Jones (1943) include no separate description of this dislocation but simply mention the possibility of its occurrence. Many reported cases have been associated with fracture of the upper end of the humerus which may take the form of a compression fracture of the anterior aspect of the anatomical neck closely resembling the postero-lateral defect in the humeral head which may be observed in recurrent anterior dislocations.

It is significant that only four of the ten cases described by Wood and Thomas were recognised at the first attendance of the patient. Of the three cases reported in this paper, the first two passed unrecognised at the hospitals to which they were first referred. The third patient was examined by a well-trained and experienced surgeon who missed the clinical diagnosis and also failed to understand the X-ray films, but a recently qualified house-officer who could not understand why the coracoid process should be so prominent called the senior surgeon back for re-examination of the patient. After much discussion, the diagnosis was clinched when the head of the humerus was palpated behind the scapula. What is the explanation of this unsatisfactory state of affairs? What is the remedy?

Part of the explanation lies in the rarity of the injury which, being unsuspected, is not recognised when physical signs are so masked by swelling. Moreover, these cases are usually dealt with as emergencies by house surgeons who are provided with no more than a single radiograph taken in the antero-posterior plane—a projection in which they fail to recognise any abnormality. Such failure is quite understandable and the remedy is obvious. The same rule which is applied to the radiographic examination of long bones must apply to the shoulder joint, in all recent injuries there must be provided either a stereoscopic pair of radiographs, or radiographs taken in two different planes. For the radiologist, stereoscopic examination meets all requirements, but these films cannot be viewed by the surgeon until they are dry and moreover experience is required for their correct interpretation. Therefore in emergency work an alternative is necessary and the choice lies between 1) transthoracic lateral projections, 2) vertical projections with the tube in the axilla or with a curved cassette in the axilla, and 3) profile projections in the postero-oblique axis with the patient erect.

Transthoracic lateral views display the upper part of the humerus satisfactorily but the shoulder joint is not well shown except in patients who are very slender and for this reason it is not a satisfactory projection. Vertical views with the tube in the axilla are often impracticable unless there is a free range of abduction movement of the shoulder joint, but, by reversing the positions of the tube and the film, and loading the film in a curved cassette, a satisfactory lateral view of the shoulder joint can usually be obtained (Fig. 1). If a vertical view with curved cassette is impossible the postero-oblique or profile view of the scapula

gives a satisfactory lateral projection of the shoulder joint in patients of average thickness—a projection which is interpreted readily by surgeons. These views are all standard radiographic positions and they are described and illustrated by K C Clark (1941)

### CASE REPORTS

**Case 1** E S, female, aged 44 years—Injured in a brawl. Her doctor sent her to hospital with a diagnosis of dislocation of the left shoulder joint. Radiographic examination of the shoulder included only an antero-posterior view and this was believed to show no abnormality. Physiotherapy was ordered. After five weeks her doctor was still convinced of the accuracy of his original diagnosis and sent her to the Royal Victoria Infirmary, Newcastle, where the orthopaedic surgeon suspected a posterior dislocation. There was marked flattening of the anterior aspect of the shoulder and complete loss of humero-scapular movement. Radiographic examination included antero-posterior and vertical curved cassette projections.



FIG 1

Vertical projection of the normal shoulder joint with tube in the axilla and cassette above the shoulder

The antero-posterior view showed internal rotation of the humerus, and elevation of the humeral head. The vertical film demonstrated posterior dislocation of the humeral head together with a compression fracture of the anterior aspect of the anatomical neck of the humerus with impaction of the posterior margin of the glenoid. Reduction was successful.

**Case 2** A H, male, aged 60 years—Injured by a fall of stone in a pit. He was sent to hospital with bruising of the left shoulder. A radiograph in the antero-posterior plane was considered to show no abnormality and the man was discharged home. Five weeks later his doctor sent him to the Orthopaedic Department of this Infirmary but the diagnosis was not suspected until further radiographs were examined. Stereoscopic views were taken. Reduction was attempted unsuccessfully. Five weeks later another antero-posterior film and a vertical projection with curved cassette were obtained, the first showed overlapping of the glenoid.



FIG 2

Case 2 Antero posterior radiograph shows slight overlap of the shadows of head of the humerus and glenoid and elevation of the humeral head. From this view alone surgeons might well have difficulty in establishing the diagnosis of posterior dislocation.



FIG 3

Case 2 The vertical projection shows backward dislocation of the shoulder joint with fracture of the posterior margin of the glenoid and a defect in the anterior margin of the humeral head from which a piece of bone has been detached.



FIG 4

Case 3 Antero-posterior radiograph of the right shoulder which is dislocated posteriorly. In this projection the humerus is seen to be internally rotated.



FIG 5

Case 3 Radiograph in vertical projection of the shoulder joint shows the posterior dislocation quite clearly.

by the humeral head and rotation of the scapula so that the whole length of the spine was visible (Fig 2) In the vertical view, posterior dislocation of the humerus was evident and there was an associated fracture of the posterior margin of the glenoid, a defect was visible in the humeral head from which a piece of bone had been detached (Fig 3)

**Case 3** T C, male, aged 43 years—Struck the front of his right shoulder against the back of a lorry while cycling, and was brought immediately to the Royal Victoria Infirmary, Newcastle-upon-Tyne Examination showed that the right upper limb was held internally rotated and extended at the elbow The outline of the shoulder appeared to be normal, but on palpation, the coracoid process was unusually prominent No increase in the vertical circumference of the shoulder was shown by measurement Ruler tests showed no flattening of the contour of the shoulder The antero-posterior radiograph showed internal rotation of the humerus with the tuberosities overlapping the glenoid (Fig 4) The vertical film, which was obtained in the almost complete absence of any abduction movement of the shoulder by lateral flexion of the spine towards the affected side and the use of a curved cassette, demonstrated the dislocation clearly (Fig 5) A transthoracic view of the humerus was also taken and it showed the dislocation but much less satisfactorily than in the vertical view Reduction was successfully achieved by traction upon the limb

#### SUMMARY

Posterior dislocation of the shoulder is an unusual injury and there is often much delay before the diagnosis is made Nevertheless, if the condition is borne in mind when examining the patient and studying the X-ray films the diagnosis should not be missed A single antero-posterior radiograph of the shoulder joint is inadequate For the radiologist a pair of stereoscopic films is desirable, but for routine emergency work in hospital other projections are necessary A vertical view should be taken, either with the limb abducted and the tube in the axilla, or with the tube above the shoulder and a curved cassette in the axilla When this is impossible a profile or posterior oblique view of the scapula may be substituted

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*Note*—The paper by Thomas reviews the literature from 1804 to 1937

# SQUAMOUS-CELLED CARCINOMA OF THE NAIL BED

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Squamous-celled epithelioma of the nail bed or sulcus is a well-known but uncommon type of neoplasm, examples of which have been recorded by Sigel (1937), Bunnell (1944), and Willis (1948). It is often mistaken for chronic paronychia. The insidious progress of the tumour, and the frequency with which it is wrongly diagnosed, make it of interest and importance.

The tumour must be distinguished from malignant melanoma of the nail. Both are found more often in the fingers than the toes, and the thumb is the digit most often affected, the right more so than the left. Some fifteen cases involving the hand have been recorded in



FIG. 1

Radiograph of both thumbs in Case 1. The terminal phalanx of the left thumb had already been amputated for what was believed to have been a whitlow. There is now almost complete destruction of the proximal phalanx.

the literature, mostly in men over the age of sixty years. There is often a history of trauma or infection which proved resistant to treatment.

Metastases in the phalanges of the hand from bronchial carcinoma, as described by Colson and Willcox (1948), must also be considered in the differential diagnosis.

## CASE REPORTS

The three cases described here are sufficiently typical to make a general description of the history, progress, and pathology of these tumours unnecessary.

**Case 1**—A man, aged seventy-three years, had been treated by his doctor for a whitlow of the right thumb. The condition proved resistant to conservative treatment and radiographs

showed erosion of the terminal phalanx, disarticulation was therefore performed at the interphalangeal joint. The scar broke down and two or three minute sinuses discharged material which the patient likened to small quantities of tooth-paste.

Seven months after first coming under observation the sinuses were still present, but without signs of inflammation. The remaining part of the thumb was thickened, the overlying skin was red and there was slight tenderness. Radiographs (Fig 1) showed almost complete destruction of the shaft of the proximal phalanx, leaving the base of the bone and a few flakes at the distal end.

The patient died of a perforated duodenal ulcer. Necropsy showed no evidence of visceral metastasis or of a primary tumour elsewhere. The axillary glands were not examined. Section of the thumb showed that the proximal phalanx was largely replaced by a white tumour (Fig 2). Histological examination showed that it was a heavily keratinised squamous-celled epithelioma invading the bone (Fig 3).



FIG 2



FIG 3

Section of the thumb at post-mortem examination shows that the phalanx is replaced by a white tumour (Fig 2). Microscopic examination shows a heavily keratinised squamous-celled carcinoma with prickly cells invading the bone (Fig 3—stained haematoxylin and eosin— $\times 10$ ).

**Case 2**—A man, aged sixty-six years, had a whitlow of the thumb which resulted in loss of the nail. It was treated by fomentations. Three years later the thumb swelled and became painful. Amputation was performed.

The specimen showed a tumour 3 cm  $\times$  1 cm  $\times$  2.1 cm at the tip of the thumb in the region of the nail which was missing. An ulcer with necrotic base and indurated thickened edges was visible in the nail bed. The cut surface presented a pink-white mass with haemorrhagic areas towards the centre. The terminal phalanx was completely destroyed.

**Case 3**—A woman, aged seventy years, had noticed swelling of the terminal phalanx of the right middle finger for three years. After one and a half years the skin broke down but radiographic examination showed no bone involvement. Amputation was performed.



The specimen presented a tumour 1.5 cm  $\times$  1 cm  $\times$  1.1 cm lying under the nail and protruding distally. The skin over the tumour was pale, and close to the nail margin there was a small ulcer with thickened raised edges. The cut surface of the tumour was in parts white and necrotic, and it was invading the terminal phalanx. Histological section showed an atypical squamous-celled carcinoma invading bone.

**Comment**—The frequency of bone involvement in squamous-celled carcinoma of the nail bed is greater than previous descriptions would suggest. The liability to metastasis in the axillary glands makes their removal, as well as amputation of the digit, the treatment of choice.

My grateful thanks are due to Professor W. Newcomb and Dr R. Pugh of the Pathology Department at St Mary's Hospital for their help, and to Mr V. Z. Cope for permission to publish Case 3.

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# HORIZONTAL APPROACH TO THE MEDIAL SEMILUNAR CARTILAGE

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During the recent war it became apparent that the results of removing a semilunar cartilage varied considerably both with regard to immediate freedom from effusion and ultimate function of the joint. In the first year, many end-results were unsatisfactory, but subsequently much more satisfactory results were obtained when better selection of cases before operation was enforced. Such selection however, did nothing to elucidate the cause of some defective results which can follow meniscectomy—it evaded the question as to why results were variable, why there was so little relationship between success in the end-result and the amount of cartilage removed, and why the mere existence of ligamentous laxity appeared so seriously to prejudice the results of meniscectomy. In considering these problems, details of technique were keenly scrutinised in one hundred and fifty operations, particular attention being paid to 1) size of the incision, 2) direction of the capsular incision, 3) double incisions with separate removal of the posterior horn, 4) division of the medial collateral ligament (Tavernier), 5) total meniscectomy as compared with removal of the displaced portion alone, 6) suture materials—catgut, thread, and no synovial suture, 7) haemostasis, using local anaesthesia without tourniquet, 8) post-operative dressings—pressure bandage alone, bandage with back splint, or bandage with plaster cylinder, 9) early or late ambulation and exercise.

It was sometimes evident that the size of the capsular incision was at least one factor accounting for post-operative trouble—it was noted that the smaller the incision the less was the likelihood of early or late effusion. Occasionally it was noticed that the scar became thickened, indurated, and of almost cartilaginous consistency. With the palpating finger resting on the scar an unpleasant click could be felt as the joint was extended actively from the flexed position. Those scars which were suspected as being a source of mechanical trouble were always vertical or oblique, and it seemed possible that the trouble might be due to movement of the scar from the articular to the non-articular surface of the femoral condyle. One such scar, which was markedly nodular, was removed. Beneath it was discovered a pannus extending on to the articular surface of the femoral condyle. In transit from the non-articular to the articular surface of the femur the scar produced a click on the bony ridge which separates these two surfaces. On its synovial surface the scar showed as an irregular white line, hard and gritty, and with histological evidence that there were no mucous cells on the synovial surface so that scar tissue was exposed in the joint cavity.

In view of these findings it was decided to use a horizontal incision at the level of the head of the tibia so that the scar could have no contact with the femoral articular surface (Fig 1). This approach was condemned by Alwyn Smith (1928) for the reason that, in his view, it gave inadequate exposure and endangered the medial collateral ligament. Only brief reference was made to it by Abbott and Carpenter (1945) and Smilie (1946). In Manchester it has been used for many years by Sir Harry Platt.

## OPERATIVE TECHNIQUE

A two-inch incision is made horizontally at the level of the head of the tibia from the medial border of the ligamentum patellae to the medial collateral ligament. The capsule is incised along the same line. The upper lip of the divided capsule is then dissected from the underlying synovial membrane and retracted upwards. The synovial membrane is opened along the upper border of the medial meniscus. The level of this incision is determined by first making a half-inch opening into the small synovial sac which lies below the meniscus, introducing a blunt hook, and passing it from below to the upper border of the meniscus.

By cutting down on to the point of the hook the definitive incision into the synovial cavity can thus be made at the lowest level. The anterior attachment of the meniscus is divided and vision into the joint, which till then has been restricted, becomes unobstructed. When the medial collateral ligament is retracted the low angle of vision into the joint by this approach is appreciated (Fig 7). The rest of the meniscus is removed in the usual way. In closing the synovial membrane the suture should be started near the medial collateral ligament while the knee joint is still flexed (Fig 9). Having started the suture at this point the joint must be extended to complete the suture. This is an important point because if the joint is extended before suture is begun the posterior part of the synovial incision becomes inaccessible under the medial collateral ligament. It will be observed that the suture line lies on the head of the tibia and cannot give rise to friction against the femoral condyles in any movement of the knee. Figs 2-5 illustrate this and show how a horizontal suture obliterates the raw bed of the meniscus.

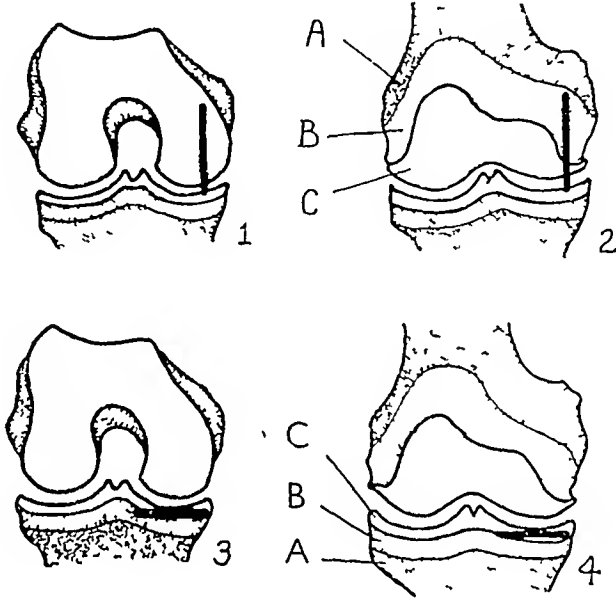


FIG 1

Showing the relation of scars to the articular surface of the femur in flexed and extended positions of the joint. A vertical scar comes in contact with the non-articular synovial-covered surface of the femur in extension, and there is a point of transition to the articular surface marked by an oblique ridge at which level the scar may produce a pinnus spreading from the non-articular to the articular surface. The horizontal scar if kept low on the tibial head bears the same relationship to the femoral articular surface in flexion and extension (A—extracapsular B—intracapsular C—articular cartilage)

### END-RESULTS

The total number of cases in which the medial meniscus was removed for undoubted lesions was one hundred and three. The results may be analysed thus

	Cases	Per cent
Perfect	35	34.0
Much better than before operation	43	42.0
A little better than before operation	15	14.5
The same as before operation	2	1.9
Worse than before operation	7	6.5
Much worse than before operation	1	0.9

Analysis based on the soldier's subjective view which did not always coincide with the surgeon's objective opinion. Thus the first two categories could not be distinguished from each other nor was there physical explanation in the case of the patient who stated that his knee was 'much worse'.



FIG 2

The medial meniscus has been removed in the cadaver through a horizontal incision which has then been sutured. The synovial aspect of the suture line is viewed from the interior of the joint by removing the lower end of the femur after dividing the cruciate ligaments. The suture line has obliterated the raw bed from which the cartilage has been excised and lies remote from contact with the articular surface of the femoral condyles.



FIG 3

The medial meniscus has been removed in the cadaver through a vertical incision which has then been sutured. The synovial aspect of the suture line is viewed from the interior of the joint by removing the lower end of the femur after dividing the cruciate ligaments. The raw bed from which the anterior half of the rim of the cartilage has been excised is visible as well as the vertical suture line which lies in relation to the femoral condyles.



FIG 4

Showing horizontal suture line concealed below the level of the head of the tibia—dissection opened out to reveal it.



FIG 5

Showing horizontal suture line concealed below the head of the tibia—dissection closed up as in the normal joint.



FIG 6



FIG 7

The synovial cavity is opened for half an inch below the level of the meniscus by cutting down on the head of the tibia and a blunt hook is passed under it and pulled out above to demarcate the upper level for the main horizontal incision (Fig 6) After detaching the anterior horn a good view of the interior of the joint is secured with a low angle of vision (Fig 7)



FIG 8



FIG 9

The rim of the meniscus is detached under direct vision with a tenotomy knife as used by Robert Jones (Fig 8) The posterior horn is seen and divided The first synovial suture is seen in Fig 9, the joint is then extended and the edges of the synovia come together easily

It was my impression that immediate recovery was quicker and less eventful after the horizontal incision than after meniscectomy through other incisions, but it will be seen that the late end-results were no better than the average of results published by other surgeons. Smilie (1946) reported completely successful results in 75 per cent of cases, and incompletely successful results in 25 per cent. Du Toit and Enslin (1945) found a similar percentage of failures, and suggested that chondromalacia of the patella might be a frequent source of imperfection in the results.

In this series of one hundred and three cases no coincident lesions such as early arthritis, ulceration of articular cartilage, or ligamentous instability were discovered at operation in eighty cases, whereas such complications were recognised at operation in twenty-three cases. These two groups were analysed separately and yet no material difference was found in the percentage of successful results. The series was also divided into those cases in which removal of the meniscus was total and those in which it was sub-total, and again no material difference was found in the percentage of good and bad results. Indeed it appeared that the results of total removal were not quite as good as those of incomplete removal.

### SUMMARY

- 1 It is suggested that slow recovery and post-operative effusion after meniscectomy may often be due to "scar friction" when the incision in the synovial membrane is in contact with the non-articular surface of the femoral condyle.
- 2 The advantages of a horizontal incision are discussed, particularly with regard to early recovery.
- 3 The results of one hundred and three cases of meniscectomy are analysed. An attempt to trace the cause of incompletely successful results in 25 per cent of cases failed to show any relation to minor coincident lesions discovered at operation, or to the amount of meniscus removed.

I am indebted to Dr Ollerenshaw and Mr Kilshaw of the Department of Medical Photography for their co-operation in producing the illustrations.

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# KNEE JOINT CHANGES AFTER MENISCECTOMY

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This paper records an investigation of changes found in the knee joint at intervals ranging from three months to fourteen years after meniscectomy. In a search of the literature only one reference to these changes has been found. Vandendorp, Bastien, and Vandecasteele (1939-40) observed in a few subjects that there was narrowing of the joint space and broadening of the femoral and tibial condyles on the operated side of the joint, but they offered no explanation of their findings.

## RADIOLOGICAL STUDY

After excluding all cases with definite osteoarthritis, a comparison was made between the pre-operative and post-operative X-ray films in one hundred and seven cases of meniscectomy. Owing to difficulty in securing identical views on separate occasions, the changes to be described were accepted as convincing only because they were seen repeatedly, and occasionally a film of the normal knee joint provided better comparison. The changes noted, alone or in combination, were of three types: formation of an antero-posterior ridge projecting downwards from the margin of the femoral condyle over the old meniscus site (Figs 1 and 2), generalised flattening of the marginal half of the femoral articular surface—a reaction similar to but more diffuse than the ridge (Figs 3 and 4), narrowing of the joint space on the side of operation (Figs 5 and 6) which, after lateral meniscectomy, was occasionally accompanied by apparent widening of the opposite side of the joint, in three patients this was sufficient to cause symptoms suggestive of mild valgus strain of the knee. The lateral views showed nothing of significance, nor was any change observed in the tibia apart from slight sharpening of the articular margin, insufficient to be described as osteoarthritis. It must be noted that the femoral ridge may be seen even before operation, particularly in cases with long-standing lesions of the meniscus, and sometimes in apparently normal joints. The changes have been seen within five months of operation on many occasions, but they tend to become more obvious with the passage of time. No correlation was found between clinical and radiographic findings, many knee joints with the most marked radiographic changes being functionally perfect. The frequency of such changes after medial and lateral meniscectomy was

	Total cases	No change	Ridge	Narrowing	Flattening
Medial meniscectomy	80	33 per cent	43 per cent	32 per cent	18 per cent
Lateral meniscectomy	27	50 per cent	7 per cent	40 per cent	17 per cent

Narrowing plus flattening were the commonest changes found in combination.

## INVESTIGATIONS

It is submitted that these changes result chiefly from loss of the weight-bearing function of the meniscus—a function which has not been accepted universally. Before enlarging on the problem two points must be emphasized. 1) If the normal meniscus is to take part in weight-bearing it can do so only if there is a force which prevents it from slipping away like an orange pip squeezed between the fingers. The peripheral attachments are loose and they are not designed to provide this counter-force, but there is another retaining mechanism which will be described later. 2) The elasticity of articular cartilage shows certain peculiarities (Hirsch 1944). Articular cartilage is perfectly elastic only for small loads applied for a very short time. If the load is maintained, deformation (*i.e.*, compression) continues slowly, and is not complete even after half an hour (Fig 7). Recoil on removing the load has similar characteristics: the longer the load has been maintained the smaller is the immediate rebound.



FIG 1

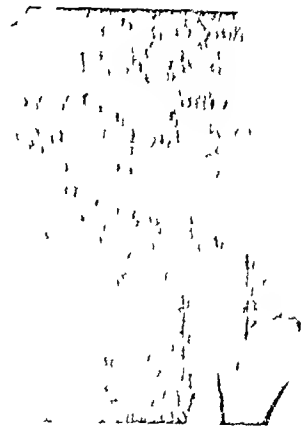


FIG 2

Patient aged forty years before operation (Fig 1) and six years after removal of the medial meniscus showing formation of a ridge on the surface of the femoral condyle (Fig 2)



FIG 3

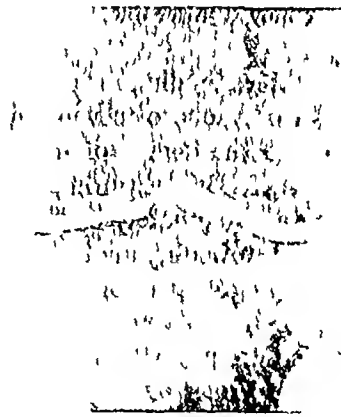


FIG 4

Patient aged thirty-six years before operation (Fig 3) and seven years after removal of the medial meniscus showing flattening of the femoral condyle (Fig 4)



FIG 5



FIG 6

Patient aged twenty-five years before operation (Fig 5) and five months after removal of the lateral meniscus, showing narrowing of the joint space laterally, and some widening medially (Fig 6)



and the longer the gradual recovery phase, while if the load has been too great or too prolonged recovery is never complete. This is not the behaviour of a homogeneous substance. The structure of articular cartilage, with its fibrillar arcades (Benninghoff 1922, 1925), and the fact that local compression was seen to cause exudation of fluid from its surface, suggested that its elastic peculiarities might be comparable to those of a sponge. By using a simple

modification of the elasticity apparatus designed by Bar (1926), strikingly similar curves were in fact produced from sponge rubber immersed in glycerin (Fig 8)

With this behaviour in mind, and in order to observe the degree of compression which occurs in the living joint, radiographs were taken of normal knee joints in full extension and in the upright position. Very careful precautions were employed to obtain identical views for three exposures: 1) in the morning before any weight had been placed on the limb, the muscles gently bracing the knee joint into extension, and all weight being on the other limb, 2) with full weight

on the knee after standing for a few minutes, 3) with full weight on the limb at the end of the day. In only one of seven subjects was the first view strictly comparable with the others because the degree of rotation and of extension both tend to alter slightly when weight is borne. By measuring the joint space in each view it was shown that the space narrowed by approximately one millimetre when weight was applied, and that by the end of the day it narrowed by another millimetre. Thus, as might be expected from the elasticity experiments, progressive compression of articular cartilage had occurred (Figs 9 and 10)

A micrometric survey was then made of those parts of the femoral and tibial articular surfaces which are normally apposed in full extension, using an apparatus devised with the generous aid of Professor Thom, Professor of Engineering at Oxford (Fig 11). By means of the lathe traversing, to which it was bolted, the gauge could be moved in the horizontal plane either sagittally or coronally for known distances. It recorded any vertical movement of the hemispherical pelotte, which rested on the articular surface and slid over it as the gauge was moved. The bone was firmly screwed to the base block. By taking gauge readings at each millimetre shift of the traversing gear it was possible to plot the curvature of a regular series of sections, sagittal and coronal, on a very large scale. These have been arranged to give perspective views of the apposed condyles (Figs 12 to 15). Two knees were thus surveyed. Both were macroscopically normal and came from

autopsy cadavers of women aged thirty and thirty-three years. The figures show how surprisingly incongruous are the joint surfaces, particularly in the sagittal plane, where much of the medial tibial condyle is almost flat and the lateral tibial condyle actually convex. Fig 16 represents diagrammatically a sagittal section through the lateral compartment of the knee joint. It is evident that until the articular cartilage has been compressed the femur

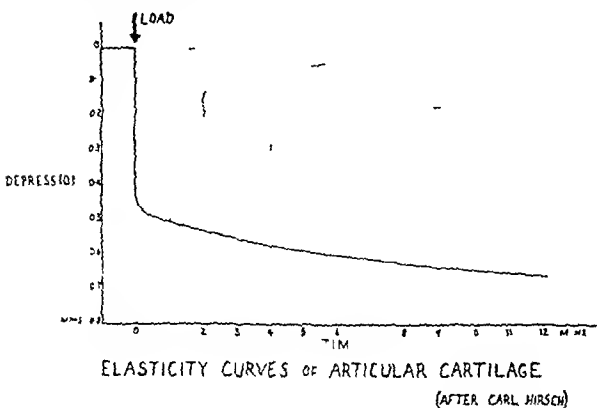


FIG 7

The dotted lines represent recovery curves when the load is removed after increasing intervals

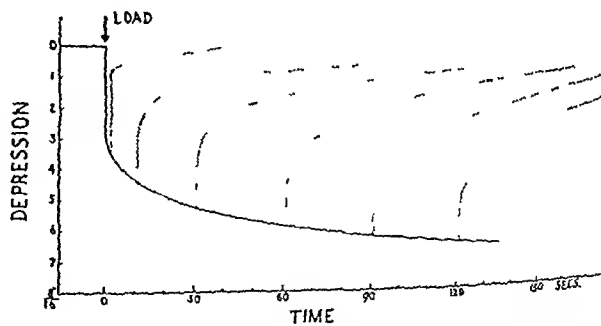


FIG 8

Recovery curves of sponge rubber in glycerin for comparison with Fig 7

cannot bear upon the meniscus as a whole. Fig 17 shows the effect of such compression. Tracings of apposed sagittal sections of the lateral femoral and tibial condyles were superimposed so that their intersections took place at a distance equal to that between the central margins of the meniscus, in this case twelve millimetres. The compression was therefore just sufficient to bring the femur down on to the meniscus. The articular cartilages were then sharing a central compression of one millimetre, which by the same method could be shown to be approximately the same in the medial compartment of the joint.

As compression increases, whether from sudden strains or in consequence of normal weight-bearing throughout the day, the circumference of the meniscus must be forced centrifugally. But in so far as the two ends of the meniscus are firmly attached to bone this force is resisted by rising tension in the stretched and elastic fibrocartilage. The greater the degree of joint



FIG 9

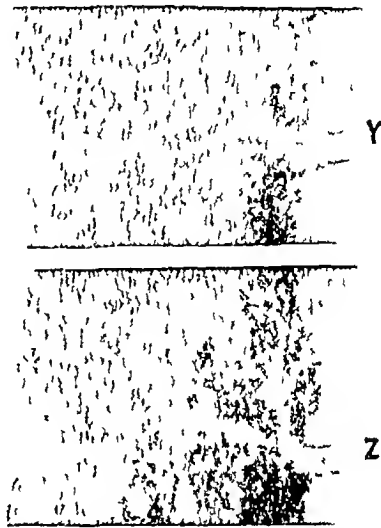


FIG 10

Fig 9 shows a normal knee joint after a night's rest without weight-bearing (X) after weight-bearing for two minutes (Y) and weight-bearing at the end of the day (Z)

Fig 10 shows a normal knee weight-bearing in the morning (Y) and in the evening (Z)

compression, the greater the circumferential tension in the meniscus. It is submitted that this tension resists extrusive forces and enables the meniscus to share in weight-bearing. That the tension is real was confirmed by stripping a knee joint of the outer soft tissues, while leaving the cruciate ligaments intact and the menisci in position but attached only by their central ends. In full extension the menisci remained slightly mobile until compression was applied, when the periphery of the menisci at once became hard and tense.

### DISCUSSION

Meniscectomy must therefore result in relative overloading of the articular surfaces on that side of the joint, with increasing compression of the cartilage. But narrowing of the joint space after operation was seen in X-ray films of the recumbent patient, and if such narrowing is permanent, and radiographically demonstrable, it must be due either to structural

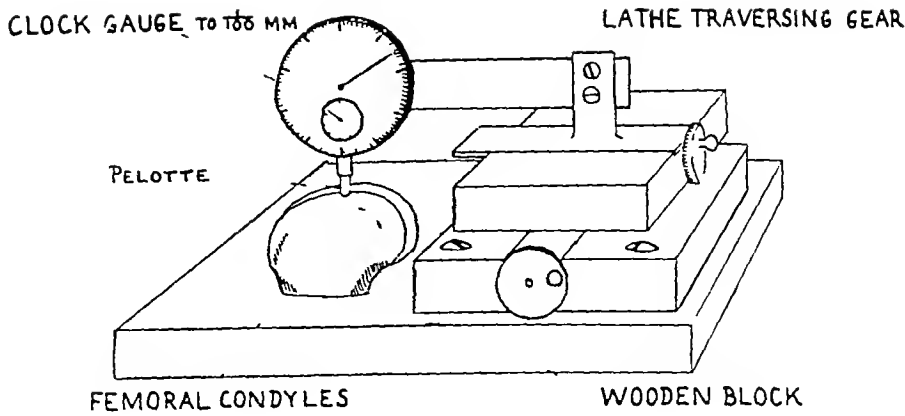


FIG 11  
Apparatus for articular survey (see text)

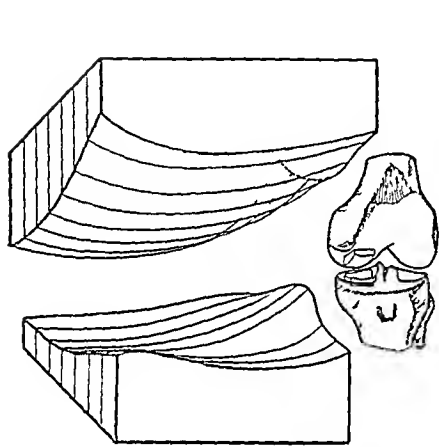


FIG 12  
Coronal section outlines of the medial condyles—interval between each section 3 mms

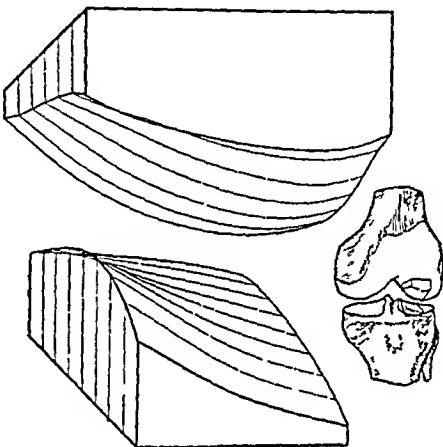


FIG 13  
Coronal section outlines of the lateral condyles—interval between each section 3 mms

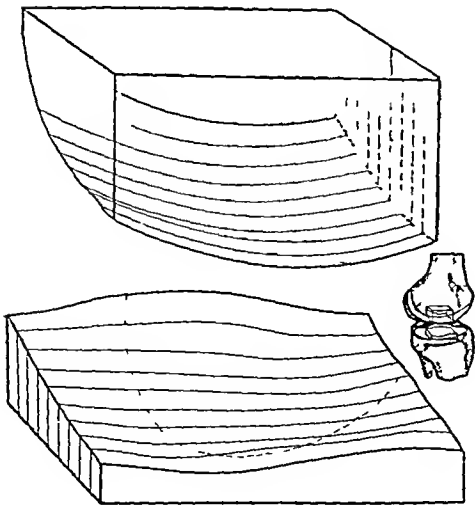


FIG 14  
Sagittal section outlines of the medial condyles—section intervals 2 mms. The dotted line on the tibial surface represents the central margin of the meniscus

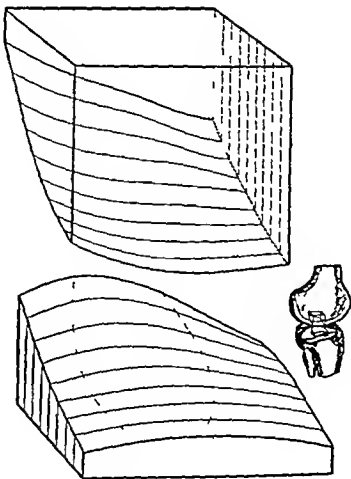


FIG 15  
Sagittal section outlines of the lateral condyles—section intervals 2 mms. The dotted line on the tibial surface represents the central margin of the meniscus

changes in the articular cartilage which impair the power of recoil, or to actual loss of tissue. The method by which loss of articular cartilage from normal wear and tear is replaced, if it is replaced at all, is still in doubt. But the work of Elliott (1936) suggests that in the adult there is amitotic cell division occurring very close to the surface. The speed of this division is controlled by 1) a nutritional factor which accounts for an increasing rate of cell division as the articular surface is approached, and 2) a mechanical factor, possibly associated with friction, which inhibits cell division and completely arrests it at the surface itself. Elliott's work was done on experimental animals and so far as can be ascertained it has not yet been confirmed in man although this writer has made preliminary investigations. MacConaill (1932) stressed the importance of the meniscus as a lubricating mechanism and stated that loss of the meniscus caused a 20 per cent increase in friction. It is reasonable to suppose that both nutritional and mechanical factors will be affected adversely when cartilage is overloaded, and the resulting interference with tissue replacement may account for the marked narrowing.

Flattening and ridge formation over the former site of the meniscus present another problem. These changes appear to be due to reaction in the overlying bone which is no longer subject to the pressure of the meniscus, although changes in the synovial blood supply at the margin may well be significant. We know that bone which is subjected to excessive pressure undergoes atrophy, and in the knee joint this may be seen in the lateral femoral condyle overlying a cystic meniscus. The condyle reacts in the opposite manner when normal pressure is removed, the mechanical effect is that of spreading the load of body weight.

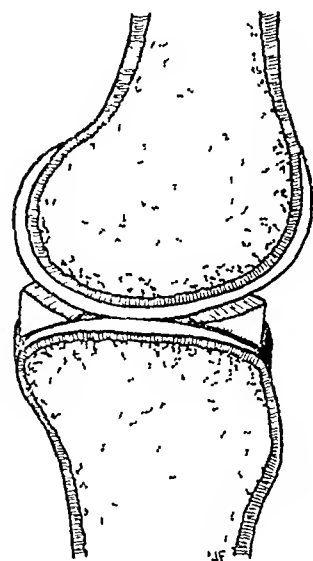


FIG 16

Sagittal section to show that the femur cannot rest on the meniscus until compression of articular cartilage has occurred

#### EFFECT ON MENISCUS OF JOINT COMPRESSION

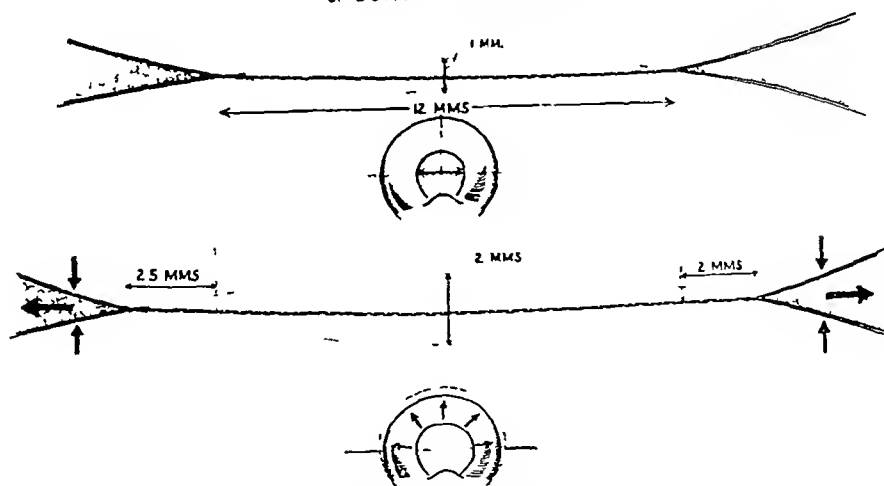


FIG 17

Superimposed tracings of sagittal sections of the tibial and femoral condyles to show the effect of joint compression in producing centrifugal displacement of the meniscus (for explanation see text)

The final problem is why the findings should be inconstant. There appear to be two possible explanations: 1) variations in the reserve or safety factor of individual joints about

which we know so little, 2) variations in the speed and completeness of regeneration of the meniscus. In this series, the results of investigation by arthrography have been inconclusive, a knee with no changes whatever in the articular cartilage or bone was shown to have almost no replacement of the meniscus, while another with ridge formation had fibrous replacement of the meniscus almost to the normal size. Arthrograms also suggested that the ridge consists solely of bone and that the articular cartilage may still have an even and normally curved surface, because the thickness of the cartilage diminishes rapidly as the apex of the bone ridge is approached. It is worth remarking that in dogs, Bruce and Walmsley (1937) found that regeneration of an excised meniscus was still progressing and not yet complete even after five months, while Pfab (1927, 1928), Dieterich (1931), and King (1936) found evidence of degenerative changes in the overlying femoral condyle.

### SUMMARY AND CONCLUSION

Changes in the knee joint after meniscectomy include ridge formation, narrowing of the joint space, and flattening of the femoral condyle. Investigations suggest that these changes are due to loss of the weight-bearing function of the meniscus. Meniscectomy is not wholly innocuous, it interferes, at least temporarily, with the mechanics of the joint. It seems likely that narrowing of the joint space will predispose to early degenerative changes, but a connection between these appearances and later osteoarthritis is not yet established and is too indefinite to justify clinical deductions.

My thanks are offered to Sir Harry Platt the staff of the Wingfield-Morris Orthopaedic Hospital and in particular to Professor H. J. Seddon for much helpful advice to Mrs Crossley of the Photographic Department and Miss Robins of the X-ray Department for their patience and skill and to Professor Thom and Mr Lund of the Oxford University Engineering Laboratory for generous help in micrometric joint surveys.

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# THE CONGENITAL DISCOID MENISCUS

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Thirteen hundred meniscectomies, performed in the seven-year period 1941-48, included twenty-nine congenital discoid menisci. Each specimen was photographed, preserved, and annotated, together with relative clinical data. The material thus available for investigation, by comparison with any personal series hitherto described, presents a unique opportunity for the study of an interesting anomaly of development. In this article the anatomical and pathological features will be described, the lesions classified, and certain conclusions drawn. It is not proposed to discuss the comparative anatomy of the menisci or the development of the knee joint. That the menisci exist as cartilaginous discs at an early stage of development, and that the congenital discoid meniscus is due to occasional persistence of the foetal state, is not in question.

*Classification*—Study of the specimens suggests that three types of congenital abnormality may be recognised, each with distinctive features, and each susceptible to characteristic injuries corresponding to the anatomical type. The classification is of course arbitrary, the types represent no more than stages of arrest of a natural process of development, and infinite variations are possible. The two extremes, "gross abnormality" and "approaching normal," have been called—1) primitive, and 3) infantile, a type somewhere between is described as—2) intermediate.

## THE PRIMITIVE DISC

If it is accepted that the shape of a normal meniscus is the result of gradual absorption during the latter half of foetal life of the central part of an originally complete plate, then it is reasonable to suggest that the more complete the disc, and the greater its breadth and thickness, the earlier the absorptive process must have ceased. The distinctive feature of the primitive disc is not so much its size, which varies within wide limits according to the age, sex, and build of the patient, but the lack of any suggestion that it was ever intended to be a meniscus (Fig 1). The whole area where there is normally contact between the femur and tibia is filled in, so that, not only is there no point of direct contact between the bones but, the opposing articular surfaces are actively separated by fibrocartilage of a thickness which may be as great as 6 millimetres. The central free margin is thick, it is the shortest of all three types and it stretches almost directly between the anterior and posterior central attachments. The outline of the edge varies in form. It is often convex with a small notch at each extremity.

*Measurement of the thickness of primitive discs*—It has generally been assumed that the periphery of a congenital disc is thicker than that of the normal structure. In order to learn whether or not this assumption was correct, and if so, whether it applied to all three types, each specimen was measured at the deepest point in the middle segment. Of fifteen primitive discs, the thickest measured 9.75 millimetres, the thinnest 4.5 millimetres, and the average 7.6 millimetres. To compare these figures with the normal, thirty non-discoid lateral menisci, the subject of a variety of different tears, were taken at random, the depth of the periphery was measured at the same point. The thickest measured 10.5 millimetres, the thinnest 5.5 millimetres, and the average 7.5 millimetres.

In the primitive disc, unlike other varieties of disc and the normal meniscus, the depth of the free central margin is of measurable thickness. In the twelve specimens in which it

\* *Paper read at the combined meeting of the American, British and Canadian Orthopaedic Associations June 1948.*

was undamaged the greatest depth recorded was 6 millimetres, the least 2.5 millimetres, and the average 3.5 millimetres. It should be noted that these measurements were made on preserved specimens in which the degree of shrinkage during preservation is unknown, so that they must not be accepted as accurate measurements of menisci in the normal state. They are, however, comparable with each other, and it is clear that there is no less wide



FIG 1



FIG 2



FIG 3

### Three types of congenital discoid meniscus

*The primitive type* (Fig 1) shows a complete disc without any suggestion that it was ever intended to be a meniscus: the central zone and the short free central margin are thick. *The intermediate type* (Fig 2) is less massive and less complete: it is thinner to the point of transparency in the central zone. *The infantile type* (Fig 3) approaches the normal differing in the greatly increased breadth of the middle segment.

variation in the depth of the peripheral rim of primitive discs than in normal lateral menisci. Primitive discs do, of course, occur with a periphery which is thicker than the normal, but the average thickness of a number of specimens is no greater than that of a similar number of normal lateral menisci. The comparative increase of thickness of primitive discs applies to the central unabsorbed portion, and especially to the free margin, but not to the periphery.

**Injuries of the primitive disc**—As might be expected, injuries of congenital discs are more extensive and more unusual in the thick and complete primitive types than in those which more closely resemble the normal structure. The thick central part of these discs, being interposed between the femoral and tibial condyles, is subject to direct compression, as well as to the antero-posterior and rotatory strains to which the normal meniscus is subject. The lesions correspond to the strains imposed, namely: 1) horizontal cleavage, resulting directly from the thickness and completeness of the disc, and 2) longitudinal and transverse tears such as may be sustained by any lateral meniscus.

**Horizontal cleavage**—Splitting of the fibrocartilage in its transverse or narrow axis may occur in the normally shaped adult meniscus in several ways, for example when the centrally displaced part of a longitudinal tear rotates in its long axis and is trapped between the condyles, or when two opposing edges of a tear impinge on one another, as in the incomplete transverse tear of the lateral meniscus which has been described elsewhere (Smilie 1946), or in a joint in which the accessory supporting structures are so lax that the meniscus can rotate in its long axis. None of these mechanisms can apply in the case of congenital discs. The horizontal split is due to continuous movement of the superior on the inferior surfaces. While the superior surface claims the normal accessory relationship to the moving femoral condyle, the inferior surface is fixed, relatively firmly, to the tibial head (Fig 4a). Continuous flexion and extension movement, aided by rotatory movement, lead to a horizontal line of cleavage between the two surfaces (Fig 4b). That this explanation is correct is proved by specimens in which there is a space between the superior and inferior surfaces, extending throughout a large part of the total area of the structure, and yet in which external examination reveals no sign of injury in either surface. The appearance is that of an empty cystic space within the substance of the fibrocartilage (Fig 5). This is the earliest manifestation of a lesion which, with the passage of time, becomes greatly modified by further wear and tear.

**Longitudinal tears**—Transverse tears of a primitive disc, complete or incomplete, are impossible, there is no concave margin to be stretched and torn. Longitudinal tears, however, are common. They are located usually on the inferior surface, closer to the central than to the peripheral margin. In none of the longitudinal tears of primitive discs were both surfaces divided. In this respect they differ from the longitudinal tears of ordinary menisci, and from those of the intermediate type to be described later. The penetration of one surface does, of course, produce an outside entrance to the plane of horizontal cleavage (Figs 6 and 14).

**Attenuation of the inferior surface of the disc**—Continuation of the stresses which cause horizontal cleavage gives rise to gradual destruction of the fibrocartilage until a time is reached when the inferior surface is so attenuated that it is worn away (Fig 4c). The under-surface of such a specimen shows the original horizontal split clearly defined at the margins of the crater which has been produced (Fig 7A). At this stage, contact between the condyles is prevented only by the thin superior surface of the disc. Judging by the number of specimens which show this particular feature, the thin membrane of this superior surface appears to be resistant to further destruction for some considerable time.

**Central hole in the disc**—In the last stage both inferior and superior surfaces are so worn

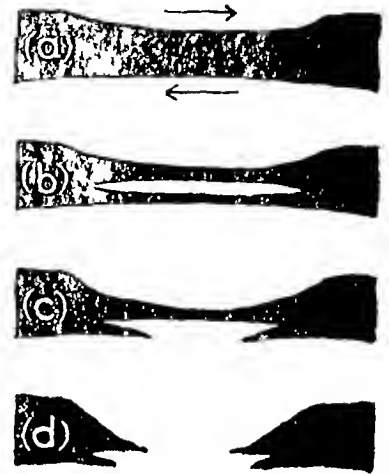


FIG 4

Diagrammatic representation of the stages of horizontal cleavage: a) the superior and inferior surfaces shift in relation to one another; b) a line of cleavage appears; c) the inferior surface wears away; d) wearing of both surfaces causes a central hole.





FIG 5



FIG 6



FIG 7A



FIG 7B



FIG 8A



FIG 8B

#### Horizontal cleavage in the primitive disc

In the specimen shown in Fig 5 both surfaces are intact but a line of cleavage has appeared within the substance of the fibrocartilage, it is outlined by lead shot introduced through a slit cut in the periphery (photograph with transmitted light) Fig 6 shows a specimen in which a short longitudinal tear has occurred on the superior surface entering the line of cleavage. The specimen in Fig 7A shows wearing of the inferior surface permitting the femoral condyle to sink into the meniscus the superior surface of the same meniscus shows the facet produced by the condyle (Fig 7B). The specimen in Fig 8 shows wearing of both surfaces producing a central hole the inferior surface shows the original line of cleavage at the margins of the hole (Fig 8A)

away that there is a hole in the centre of the specimen (Fig 4d) The original line of cleavage can still be seen at the margins of the hole (Fig 8A)

**Summary of the four types of injury of primitive discs**—The various stages of the lesion, and the frequency of each stage in this series, may be summarised thus 1) a plane of cleavage appears in the substance of the fibrocartilage between the undamaged superior and inferior surfaces (two cases), 2) longitudinal tears are superimposed, usually on the inferior aspect (four cases), 3) the inferior surface is worn away and a shallow crater is produced (six cases), 4) both inferior and superior surfaces are worn away, thus producing a hole in the centre of the disc (two cases)

**Ridges on the surface of a primitive disc**—Other writers have drawn attention to the presence of a ridge on the superior surface of certain specimens and have discussed the relationship of this ridge to the "snapping knee" This ridge, or wave, is said to have arisen in consequence of weight-bearing but no precise information has been offered as to the mode of origin Ridges of sufficient degree to account for "snapping knee" were noted in two specimens in this series The position varies When there is a single ridge, it runs obliquely forwards and outwards from the free central margin to the periphery, and it marks the division between a posterior facet where the femoral condyle lies in flexion, and an anterior facet where the condyle lies in extension When only one recognisable facet is present, two ridges may exist, one in front and one behind the point occupied by the femur The question arises as to whether this ridge is elevated above the natural level of the original structure, heaped up by the action of weight-bearing as has been hinted in previous descriptions, or whether there is some more simple explanation Measurements of the ridge, both at the periphery and at the central margin, show that it is no higher than the original structure The explanation is afforded by the pathological changes in primitive discs already described These ridges are due to wearing of the inferior surface which allows the superior surface to sink, so that eventually a smooth hollow is produced for reception of the femoral condyle (Fig 7A) The ridges are no more than intact strips of fibrocartilage Moreover, and in further evidence that this explanation is correct, they do not necessarily run transversely in the short axis of the disc Two parallel ridges of comparable height may sometimes be seen in the long axis of a thick specimen The significance is the same, they simply outline the medial and lateral borders of a depression produced by the femoral condyle

**Cause of the "snapping knee"**—In this series there were only four cases in which a congenital discoid meniscus was associated with the dramatic sign of "snapping knee" (see Table I) The writer has also had the opportunity of examining three other cases, two described by Middleton (1936), and one seen before 1940 and not included in this series The snap occurs as the result of sudden alteration in the usual relationship between the meniscus and the femoral and tibial condyles, the actual sound being produced by backward or forward movement of the meniscus at the moment that the femoral condyle rides over 1) the thick intact strip of fibrocartilage which forms the anterior boundary of the facet produced by the femoral condyle, or 2) the thick anterior peripheral margin of the meniscus itself

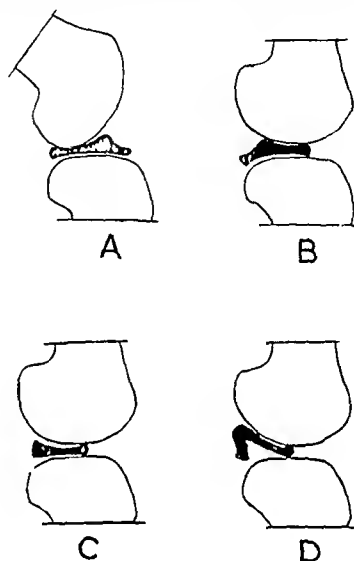


FIG 9

The cause of 'snapping knee'  
—A) relation of femoral condyle to the ridge in flexion B) relation of femoral condyle in extension C) the condyle has slipped over the anterior margin of a small disc lying horizontally in the posterior compartment D) the condyle has slipped over the anterior margin of a large disc flexed upon itself in the posterior compartment

It is evident that no alteration in the accustomed relationship between the meniscus and the opposing condyles can occur until antero-posterior mobility of the meniscus is increased much above the normal. The deeper the femur sinks into the substance of the fibrocartilage, the closer the meniscus must follow movements of the condyle, and the greater must be the subsequent stretching of both anterior and posterior peripheral attachments. Eventually, perhaps because of some trivial incident which occurs when the knee joint is in a position just short of full extension, the condyle mounts the ridge, or slips over the anterior periphery, and drives the meniscus backwards. This action completes the stretching, or even tears the anterior peripheral attachment so that the meniscus comes to lie partly, or completely, behind the femur (Figs 9B, 9C, and 9D). Return to the original position takes place at a point short of full flexion when the condyle mounts the ridge from the opposite side and drives the structure forward again.

In two cases in this series the snap was due to a ridge (Figs 9A and 9B). At operation the peripheral attachment was found to be stretched. When it had been divided, the margin of the meniscus was seen appearing just beneath the femoral condyle. Traction on the periphery, or further flexion of the joint, made the meniscus slip forwards so that the femoral condyle lay in the large posterior facet.



FIG 10

Inferior surface of a primitive disc which lay flexed acutely upon itself behind the femoral condyle in extension; the anterior peripheral attachment was completely torn. Note the groove corresponding to the apex of the curve.

In the other two cases a snap was produced by the condyle slipping over the thick anterior margin so that the meniscus lay behind the femoral condyle. In one, the peripheral attachment took the form of a transparent film of tissue stretched over the articular surface of the tibial table, the meniscus was small enough to lie horizontally behind the condyle (Fig 9C). In the second, the peripheral attachment was completely torn, in this case the disc was so large that it could not be accommodated except when flexed acutely upon itself behind the femur (Fig 9D). The specimen showed a deep furrow which corresponded to the apex of the curve (Fig 10).

**Other sequelae of horizontal cleavage**—Three primitive discs, each with horizontal cleavage, were discovered in the course of other operations—two during routine examination of a joint after removing a torn medial meniscus, and one in the course of an operation for osteochondritis dissecans involving the medial femoral condyle. Could there be any association between these conditions? In two cases of injury of the medial meniscus the lesion was not the usual longitudinal tear, it was an injury of the type which is associated with recurrent incidents in an unstable joint. In the third case, osteochondritis of the medial femoral condyle was due to impingement of the tibial spine. It is not unlikely that all three lesions were the direct result of instability due to horizontal cleavage in a thick, weight-bearing, lateral meniscus.

#### THE INTERMEDIATE DISC

It is difficult to define the intermediate type of congenital discoid meniscus. The title suggests that it lies midway between the primitive and infantile types of disc, but undoubtedly it resembles the primitive type more closely, so much so that it might be regarded as a subtype rather than a separate variety. The principal difference is that it is less massive, less complete, and much thinner in the central zone (Fig 2). The central margin shows two

TABLE I

No	Sex	Age	Side	Anatomic type	Outstanding features of the lesion	Cystic degeneration
1	M	18	R	Primitive	Horizontal cleavage superficial longitudinal tear of the inferior surface	Yes
2	M	33	L	Primitive	Horizontal cleavage surfaces undamaged	—
3	M	21	L	Intermediate	No obvious lesion	—
4	M	31	I	Primitive	No obvious lesion	—
5	M	25	R	Infantile	Posterior peripheral longitudinal tear	Yes
6	M	27	L	Primitive	Horizontal cleavage inferior and superior superficial tears resulting in a hole in the centre	—
7	M	33	R	Infantile	Incomplete oblique tear	Yes
8	M	20	L	Primitive	Horizontal cleavage anterior peripheral detachment	Yes
9	M	29	R	Primitive	Medial cartilage Horizontal cleavage whole inferior surface worn away	Yes
10	M	20	L	Primitive	Horizontal cleavage anterior and posterior ridges resulting from wearing away of inferior surface posterior peripheral detachment	—
11	M	21	L	Intermediate	Anterior longitudinal tear	—
12	M	30	R	Primitive	Horizontal cleavage both surfaces worn away resulting in a hole in the centre	—
13	M	25	R	Primitive	Horizontal cleavage anterior peripheral longitudinal tear	—
14	M	22	L	Infantile	Incomplete oblique tear	Yes
15	F	25	L	Primitive	Horizontal cleavage single ridge resulting from wearing away of the inferior surface	—
16	M	51	L	Infantile	Incomplete oblique tear	—
17	M	18	R	Primitive	Horizontal cleavage under-surface worn away	—
18	M	36	L	Intermediate	Posterior longitudinal tear	—
19	M	17	L	Infantile	Structure undamaged torn from all peripheral attachments in the course of dislocation of knee	—
20	M	14	L	Primitive	Horizontal cleavage superficial longitudinal tear of the inferior surface	—
21	M	51	L	Primitive	Horizontal cleavage inferior surface worn away	Yes
22	M	17	R	Intermediate	Posterior longitudinal tear	—
23	F	20	R	Intermediate	Anterior peripheral detachment	—
24	M	26	L	Intermediate	Posterior peripheral detachment and posterior longitudinal tear	—
25	M	26	R	Primitive	Horizontal cleavage superficial longitudinal tear of the superior surface	Yes
26	M	19	L	Infantile	Incomplete oblique tear	Yes
27	F	15	R	Primitive	Horizontal cleavage anterior portion inferior surface worn away gross stretching anterior peripheral attachment	—
28	M	16	R	Intermediate	Structure undamaged gross stretching of the posterior peripheral attachment	—
29	M	16	L	Intermediate	Posterior peripheral detachment and posterior longitudinal tear	—

In Cases 10 15 23 and 27 there was the dramatic sign of snapping knee which made pre-operative diagnosis easy The correct diagnosis was also made before operation in Case 29 (which was the second knee in a bilateral case) and in Case 26 where success was attributable to no more than "intelligent anticipation"

notches, one behind the anterior central attachment and one in front of the posterior central attachment. Between the notches is a convex area directed towards the centre of the joint. But the characteristic of this type is not so much the outline of the free border, which may be seen also in the primitive variety, as the thinness of the border, even to the point of transparency, a feature which is present, if in lesser degree, throughout the whole central region. This in fact is the type, and the only type, to which the vague words so often used, "thin and transparent on the medial border," actually apply. The depth of the periphery of eight such specimens varied between 5 and 6 millimetres. The rim was thus less deep than the normal average.

**Injuries of the intermediate disc**—The characteristic injury sustained by congenital discs of the intermediate type is a peripheral or extra-peripheral longitudinal tear. Five specimens showed posterior lesions. In four it took the form of a longitudinal tear. Two of these also showed posterior peripheral detachment (Fig 11). In the fifth case



FIG 11



FIG 12

#### Intermediate discs showing posterior longitudinal tears

Fig 11 shows a specimen with posterior peripheral detachment and posterior peripheral longitudinal tear. Fig 12 shows a longitudinal tear entering at the posterior notch.

the posterior peripheral attachment was markedly stretched. Two showed anterior lesions, one taking the form of a longitudinal tear, and one a complete detachment of the anterior segment. In one case there was no obvious injury. In no specimen was there evidence of a compression lesion of the central zone such as was seen in the primitive disc. It appears, therefore, that injuries sustained by congenital discs of the intermediate type correspond more or less exactly to the usual injuries of normal lateral menisci. The intrusion of a thin central zone between the femoral and tibial condyles does not appear to exert any influence on the type of injury sustained.

#### THE INFANTILE DISC

In some respects this type resembles the meniscus as it exists in the full-term foetus. It is the variety of congenital abnormality which most nearly approaches the normal structure, differing only in the very greatly increased breadth of the middle segment. One of the characteristic features of the normal lateral meniscus is the uniformity of breadth of the anterior, middle, and posterior segments. Nevertheless, there is often increase in the width of the middle segment which is considered to lie within the bounds of normality. Only cases in which this increase was unmistakably abnormal have been included in this group (Fig 3).

There were six such cases. The depth of the periphery varied between 9.5 millimetres and 6 millimetres, the average was 8 millimetres. The periphery was thus slightly thicker than the normal average. The fibrocartilage tapers to a sharp crescentic edge, as in the normal structure.

**Injuries of the infantile disc**—The normal lateral meniscus is subject not only to the usual peripheral and extra-peripheral longitudinal tears, but also to an intrinsic lesion, namely, incomplete transverse or oblique tear (Smilie 1946). This particular injury occurs on the lateral side for the reason not only that the meniscus is more broad but also that it is a segment of a smaller circle than its medial counterpart. Thus any force which tends to straighten the concave margin is likely to cause a transverse tear. It is to be expected that liability to such a tear would be greater in the infantile type of disc because the concave edge is even less in a position to withstand strains which tend to increase the distance between the anterior and posterior segments. Four of the six specimens demonstrated this lesion (Fig. 13). There



FIG. 13

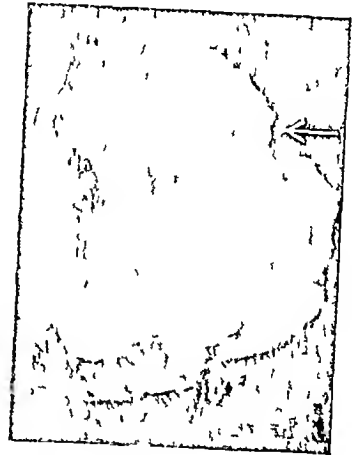


FIG. 14

#### Infantile and Primitive discs with tears

Fig. 13 shows an infantile disc with an incomplete oblique tear. Fig. 14 shows a primitive disc with surface split entering horizontal cleavage and multiple cysts in the peripheral zone.

was one which showed a posterior peripheral longitudinal tear, and one in which the meniscus had been torn from its posterior peripheral attachment.

*Two anatomical types of normal lateral meniscus*—It has already been stated that thirty ordinary lateral menisci were taken from the general collection for the purpose of comparing the depth of the periphery with that of the normal structure. In the course of taking measurements it became obvious that there were, in general, two anatomical types—one in which the anterior, middle, and posterior segments were of uniform breadth and where the lesion was either a longitudinal tear or a peripheral detachment of the posterior segment, and one in which the middle segment was much more broad and in which the lesion was almost invariably an incomplete transverse tear. Comparison between these menisci, and the six discs to which the name "infantile" has been attached, make it clear that they were no more than outstanding examples of a common type which by reason of abnormality of breadth is liable to a particular injury. It is thus evident that the six cases now recorded as congenital discs of the infantile type do not represent a true picture of the frequency with which this variety occurs. Nor is it unlikely that, as a source of trouble in the knee joint, further experience may prove it to be the most important of the three anatomical varieties.

## COMPARISON OF ANATOMY AND PATHOLOGY WITH PREVIOUSLY REPORTED CASES

From the descriptions and illustrations which have been published in earlier articles, it is clear that many specimens on record correspond closely to the primitive and intermediate types here described. It is evident also that the infantile type of disc has been recognised as a congenital abnormality: for example, Bell Jones (1935) illustrated a typical specimen showing the characteristic incomplete oblique tear.

The curious varieties which have been described in some earlier papers have not been seen. There has been no case of anterior and posterior horns joined by fibrous tissue as recorded by Naughton Dunn (1934), or of reversed disc, absent posterior half, or free margins in unusual positions, as recorded by Fairbank \* (1937). It is difficult to explain such entities on embryological grounds. Some may be freaks, but it seems probable that most of them were extraordinary examples of the effects of injury on primitive discs. For example, the "reversed disc" and those with a "hole in the centre," described by Fairbank (1937) and McMurray (1942), almost certainly represent the late stages of horizontal cleavage. The "absent posterior half," and "free margins in unusual positions," are examples of peripheral detachments known to be common in the congenital abnormality.

## ASSOCIATION OF CONGENITAL DISCS WITH CYSTIC DEGENERATION

The association of cystic change with congenital malformation has been recorded by Ollerenshaw (1935), Herzmark (1936), Ober (1939), Meekison (1940), Kulowski (1940), and Kulowski and Rickett (1947). In this series nine specimens were the subject of cystic degeneration, this being the diagnosis which led to operative intervention. Cystic changes occurred in five primitive discs (Fig. 14), including the one example of medial disc (Figs. 15, 16A, 16B,) and in four infantile discs. This is not the occasion to discuss the etiology of meniscus cysts. The writer holds the view that they are traumatic in origin. If it is correct to believe that congenitally abnormal menisci are even more vulnerable to injury than normal menisci, it might reasonably be expected that the incidence of cystic degeneration would also be higher. The statistics of this series of cases cannot establish proof, but they suggest that this may be true. In a total of 468 lateral meniscectomies, 105 showed cystic degeneration—namely 22 per cent. In twenty-eight lateral discs, eight showed cystic degeneration—28 per cent.

## DISCOID MEDIAL MENISCUS

Until 1945, when Dwyer and Taylor's case was described, there appears to be no record in the literature of a discoid medial meniscus. It was accepted that the anomaly occurred only on the lateral side of the joint. The only case which the writer has seen was operated upon in 1943 and reported in 1946. This specimen, and the one described by Dwyer and Taylor, were both discs of the primitive type. It is thus evident that congenital malformations of the discoid type may occur in either meniscus, but that persistence of the embryonic state on the medial side is very rare.

**Injuries of the discoid medial meniscus**—The single specimen available for examination had originally been the subject of horizontal cleavage but almost the entire inferior surface had worn away, leaving evidence of the primary lesion only at the anterior half of the periphery (Fig. 16B), the superior surface was undamaged (Fig. 16A). In addition to the

\* By courtesy of Sir Thomas Fairbank the writer has been permitted to examine the clinical notes and original drawings of his fifteen cases: three of which were bilateral.

lesion of the substance of the fibrocartilage there was cystic degeneration and this was the diagnosis with which the patient came to operation (Fig 15). Unfortunately the exceptional nature of the case was not appreciated at the beginning of the operation and no care was



FIG 15

Clinical appearance of the knee in a case of discoid medial meniscus with cystic degeneration



FIG 16A



FIG 16B

Disc removed from the knee joint shown in Fig 15. Fig 16A shows the undamaged superior surface. Fig 16B shows the inferior surface; it is worn away; the original horizontal cleavage is seen at the periphery. (The cyst has been removed from the specimen.)

taken to preserve the attachment of the cystic mass to the meniscus, it was located at the junction of the anterior and middle thirds of the periphery. In the case reported by Dwyer and Taylor (1945) the photograph and accompanying description indicate that there was horizontal cleavage of the disc with also a longitudinal tear on the superior surface.



## SUMMARY

- 1 A personal series of twenty-nine discoid menisci is reviewed
- 2 Three anatomical types are recognised and described
- 3 The characteristic lesions incurred by each type is recorded
- 4 The anatomical and pathological features of the specimens are compared with those of cases previously recorded
- 5 A discoid medial meniscus is described, and compared with the only other specimen known to be recorded in the literature

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# SOME ANATOMICAL DETAILS OF THE KNEE JOINT

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In current texts, descriptions of the knee joint lack precision in certain details, and it is believed that revision of the anatomy of this important joint might be of value. It is proposed to give an account of the true capsule of the joint, the accessory ligaments, and the attachment of certain muscles.

## CAPSULE AND ACCESSORY LIGAMENTS

In order to appreciate the arrangement of the capsule and ligaments of the knee joint it is advisable to consider the joint in the foetus, and trace the changes which occur during development of the adult structure. In the foetus the joint is a simple diarthrodial structure, the capsule being attached around the articular surfaces including that of the patella. The upper end of the fibula articulates with the femur and the conjoined horizontal surfaces of the tibial plateau and upper end of the fibula are surrounded by a simple tubular capsule which is attached at its upper circumference round the articular surface of the femur. The capsule is interrupted anteriorly by a gap, to the margins of which the articular surface of the patella is attached. At this stage the joint already contains the two menisci.

### Lateral ligament of the knee joint—

As a result of the different rate of growth of tibia and fibula, the fibula is excluded from the knee joint, its upper end sinks below the tibial plateau and articulates with the tibia at the superior tibio-fibular synovial joint. The head and styloid process of the fibula pull down with them

a prolongation of the original capsule. The margin of the tibia from which capsule is lacking (having been "stolen" from it by the fibula) is that part over which the tendon of popliteus passes. This part of the capsule is the short external lateral ligament of old terminology, in current British terminology it has no name. It might be described as the deep part of the lateral ligament of the knee joint. It represents part of the true joint capsule. It is attached above to the lateral epicondyle of the femur and below to the styloid process and medial (tibial) border of the upper surface of the head of the fibula. Its free posterior border, lying over the popliteus fascia and firmly adherent thereto, constitutes the arcuate ligament (Fig 1). The arcuate ligament is attached firmly towards its upper end to the posterior arch of the lateral meniscus. Morphologically, the long external lateral ligament of old terminology (or the lateral ligament of the knee joint of current terminology) may be the degenerated tendon of peroneus longus (Bland Sutton 1884, Wheeler Haines 1941). It arises from the lateral epicondyle of the femur, in continuity with the upper part of the short external lateral ligament already described. It is inserted into the upper surface of the head of the fibula, lateral to the deep part (Fig 1). Between them the deep part of the tendon of biceps femoris is inserted, thus separating them at the head of the fibula. The long external lateral ligament (lateral ligament of current terminology) divides the tendon of biceps into superficial and deep parts.

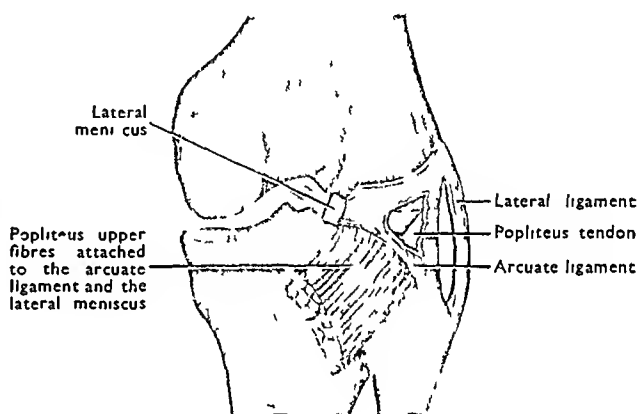


FIG 1

The popliteus attached to the lateral meniscus

**Medial ligament of the knee joint**—Like the lateral ligament, the medial ligament possibly consists of two, morphologically distinct, parts. The deep part, named in old terminology the short internal lateral ligament, has no name in current British terminology. It is part of the capsule of the joint. It is attached to the articular margins of the femur and tibia on their medial aspects and is continuous with the capsule of the knee joint in front and behind. It is attached intimately to the medial meniscus. The superficial part, which is by far the larger and the more important, arises below the adductor tubercle from the medial epicondyle of the femur and is inserted into the medial condyle of the tibia, and into the posterior part of its subcutaneous surface for a distance of one handsbreadth below the level of the knee joint. It is a broad, flat, triangular structure, and is very strong. Its anterior border is vertical, but its posterior border is oblique in opposite directions above and below the joint, so that the widest part is over the medial meniscus (Fig 2). Posteriorly it overlaps the deep part (short internal lateral ligament described on page 683), and in this situation its

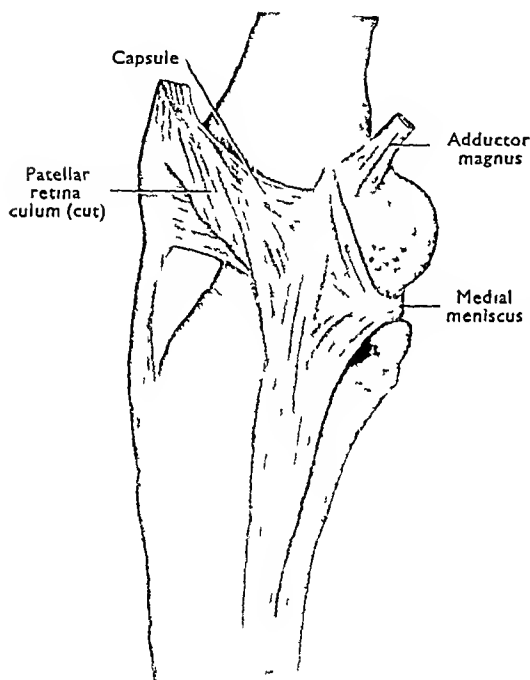


FIG 2

The medial ligament of the knee joint

fibres are attached firmly to the medial meniscus, its anterior border is free of attachment to the meniscus. According to Bland Sutton (1884) the anterior vertical part is, morphologically, the degenerated tendon of adductor magnus. The hamstring part of adductor magnus (the presemimembranosus muscle of Comparative Anatomy), which is innervated by the sciatic nerve, is inserted into the adductor tubercle. From this point downwards it is represented by the vertical part of the medial ligament of the knee joint. The deep or capsular, and the superficial or tendinous, parts of the medial ligament of the knee joint are fused into a single structure above, but they are separated below by an expansion from the semimembranosus tendon which passes forwards between them (Fig 3). This is the expansion which is often described as being inserted into the medial meniscus, in our experience it is inserted only into the tibia. Still lower, the medial ligament is separated from the tibia by the passage beneath it of the medial inferior genicular vessels and nerve. Strong retinacular fibres from the medial

border of the patella curve towards the anterior border of the upper part of the medial ligament (Fig 2). In flexion of the joint the anterior edge of the medial ligament passes backwards, thus exposing a greater extent of the medial meniscus.

**Tension of the ligaments**—Both medial and lateral ligaments of the knee joint are taut in extension, their upper attachments being placed behind the axis of rotation of the femoral condyles. They are relaxed in flexion. In flexion, moreover, a smaller surface of the femoral condyles is in contact with the tibial plateau. These two factors are responsible for the greater degree of mobility of the joint in flexion, viz, rotation and passively induced adduction and abduction. The state of the cruciate ligaments in flexion contributes to this increased mobility (*vide infra*).

**Foetal capsule in the adult joint**—Between the medial and lateral ligaments, across the front of the joint, the foetal capsule is still present with its circular gap filled by the articular surface of the patella. From the lower margin of the patella to the anterior margin of the plateau of the tibia the capsule is separated from underlying synovial membrane by a pad of fat which herniates into the joint and raises a median fold called the ligamentum mucosum,

extending into the joint as far as the anterior surfaces of the cruciate ligaments. Two alar folds extend, one on each side of the ligamentum mucosum. They have no morphological significance. The statement that they are riches of intra-articular septa is wrong. There is no evidence that primitive septa ever existed in any vertebrate knee joint (Wheeler Hames 1941). The original capsule above the patella, between it and the femur, perforates when the infant walks and thereafter communicates with a large suprapatellar bursa lying deep to the quadriceps tendon, and in the adult limb extending a handsbreadth above the joint.

Thus the foetal capsule is still present in the adult joint. It has two gaps, one allowing the popliteus tendon to emerge, and the other communicating with the suprapatellar bursa. Other gaps in the capsule for communication with bursa may occur, but they are inconstant. The added ligaments provided by the phylogenetically degenerated tendons of adductor magnus and peroneus longus, the medial and lateral ligaments respectively, greatly strengthen the joint. Posteriorly the joint is also reinforced, an expansion from the tendon of insertion of semimembranosus extends upwards and laterally across the posterior part of the true capsule. This is the oblique posterior ligament of Winslow, its upper attachment is to the lateral condyle of the femur and the intercondylar notch, rather above its margin, so that a prolongation upwards of synovial membrane encroaches a little on the popliteal surface of the femur. Loose bodies may lodge here, and elude discovery at operation. The oblique posterior ligament is a thick rounded cord of great strength (Fig 3—The figure does not show several irregular prolongations which extend from the ligament to the popliteal surface of the femur and give rise to a fenestrated appearance above the main ligamentous band).

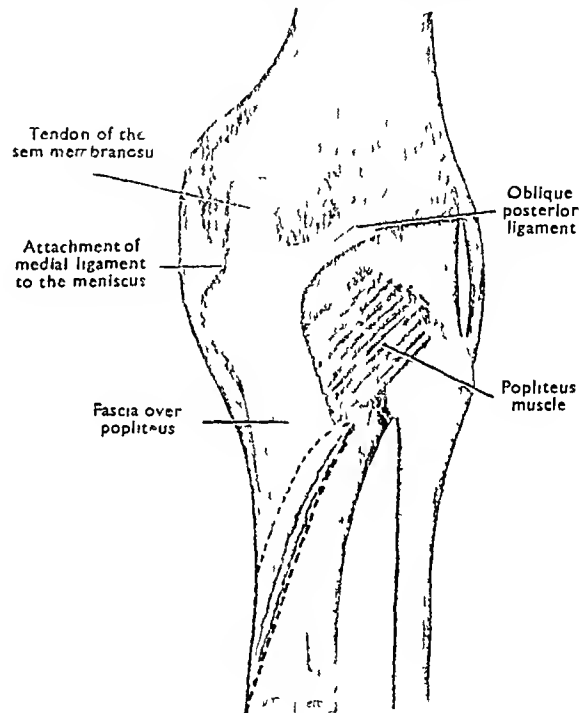


FIG 3

Posterior aspect right knee joint. Dotted line indicates attachment of soleus

#### INTRA-ARTICULAR STRUCTURES

**Cruciate ligaments**—The cruciate ligaments consist of a pair of very strong bands connecting the tibia to the femur, and they lie within the capsule of the knee joint but not within the synovial membrane. It is as though they had been herniated into the synovial membrane from behind, carrying forward over themselves a fold of synovial membrane which invests their anterior and lateral surfaces, but leaves their posterior surfaces uncovered except superiorly. They are named from their tibial origins, and cross like the limbs of the letter "X". They are essential to the stability of the knee joint. The anterior cruciate ligament is tense in extension, the posterior tense in flexion, but neither is really lax in any position of the joint. Lateral rotation of the flexed tibia unwinds them, medial rotation winds them up.

**Medial and lateral menisci**—The menisci consist of fibrocartilage, curved in shape and wedge-shaped in cross section. They are avascular except for a narrow zone at their points of attachment (Davies and Edwards 1948). The medial meniscus is attached to the tibia at its anterior and posterior horns by fibrous tissue, elsewhere the circumference is attached strongly to the capsule and posterior part of the superficial medial ligament of the knee joint (Fig 2). The lateral meniscus is likewise attached to the tibia at both horns in addition

its posterior horn is slung by fibrous tissue "ligaments" to the femur. The slings are attached to the medial condyle of the femur, in front and behind the attachment of the posterior cruciate ligament, forming the ligaments of Humphry and Wrisberg respectively (Figs 4 and 5). These ligaments are strong structures, especially the latter, and it is unfortunate that their names should have been dropped from current British nomenclature.

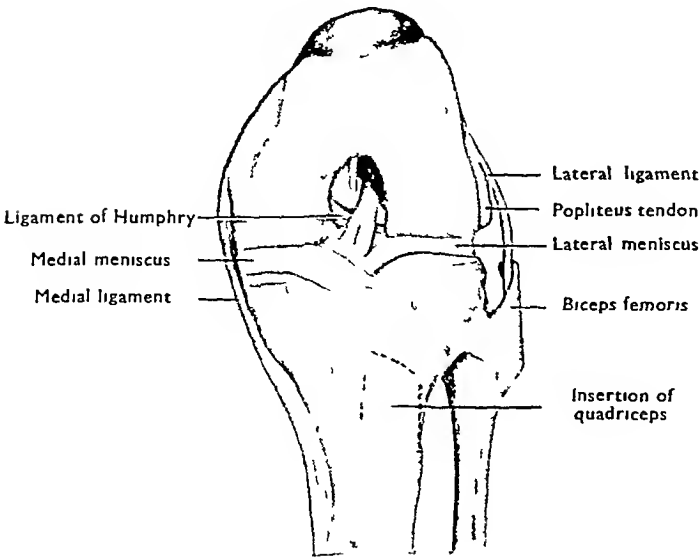


FIG 4

Interior of left knee joint from in front

The lateral meniscus is thus fixed at its horns, but elsewhere it is freely mobile, being separated from the deep part of the lateral ligament (capsule) of the knee joint by the tendon of popliteus (Fig 1). Firm attachment of the arcuate ligament to the meniscus, and attachment of the upper fibres of the popliteus muscle to the arcuate ligament and meniscus, ensure backward drawing of the posterior arch of the meniscus in medial rotation of the flexed tibia. It is the moving backwards of the meniscus in medial rotation of the leg which rounds off the posterior edge of the lateral tibial condyle, and not the tendon of popliteus, as stated in most current texts.

#### MOVEMENTS AT THE KNEE JOINT

Flexion of the joint is limited by the soft parts behind, extension is limited by tension of the medial and lateral ligaments, and the anterior cruciate ligament. Full extension is accompanied by lateral rotation of the tibia, a movement which is to some degree passive, resulting partly from the shape of the articular surfaces (the lateral femoral condyle being shorter than the medial, so that it is "used up" first) and partly from the pull on the tibia of the lowest fibres of vastus lateralis. In flexing the joint from this locked position the popliteus begins the movement by medially rotating the tibia. Popliteus, and the lowest fibres of vastus lateralis, are thus antagonists. When the joint is flexed, medial and lateral rotation of the tibia are performed by the hamstrings. The freedom which allows this rotation of the tibia results from relaxation of the medial, lateral and anterior cruciate ligaments, greater mobility also results from the fact that a smaller femoral surface is in contact with the tibial plateau in flexion. In this flexed position the posterior cruciate ligament is taut and it forms the axis around which the tibia rotates on the femur. In flexion and extension the menisci, fixed to the tibia, move with it on the femur. In rotation of the tibia in the flexed position the menisci, especially the lateral, move with the femur on the tibia. This is a characteristic feature of all joint fibrocartilages in which two separate, but often simultaneous, movements take place—for

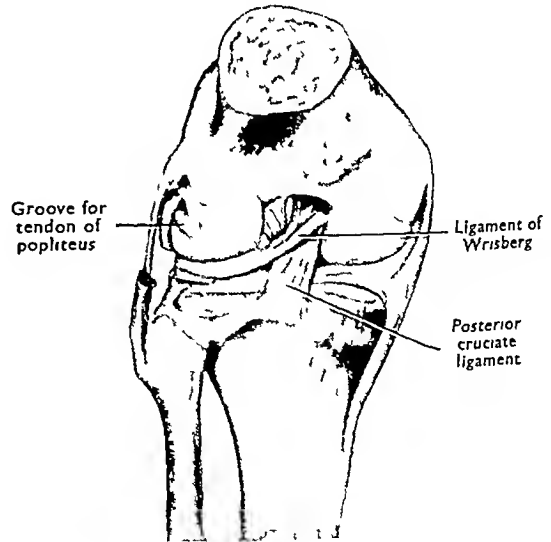


FIG 5

Interior of left knee joint from behind

example the temporo-mandibular joint which has gliding movement in its upper compartment and true hinge movement in its lower, and the sterno-clavicular joint which permits up and down movement of the clavicle in the lateral compartment, and horizontal or rotary movement in the medial compartment. It is substantially true of the knee joint that flexion and extension take place in the upper compartment while rotation takes place in the lower. The menisci also play an important part in spreading the lubricating film of synovial fluid (MacConaill 1931)

### MUSCLE ATTACHMENTS NEAR THE KNEE JOINT

Careful dissection shows that some accepted descriptions of muscle attachments in the region of the knee joint are inaccurate

**Quadriceps femoris**—The four components of this muscle are inserted into a trilaminar quadriceps tendon. Anteriorly, the rounded tendon of rectus femoris flattens immediately above the patella, and forms the anterior lamina which is inserted separately at the anterior edge of the upper border of the patella. In the middle of the thigh, contiguous surfaces of the rectus femoris and vastus intermedius are each covered by a shining aponeurosis. The aponeurosis which covers the surface of vastus intermedius is continued downwards as the deepest lamina of the quadriceps tendon, it is inserted into the posterior edge of the upper border of the patella. The intermediate portion of the tendon is a lamina formed by confluence of the central edges of the vastus lateralis and vastus medialis. The lowermost fibres of vastus medialis, almost horizontal in direction, do not contribute to the quadriceps tendon. They are inserted directly into the side of the patella, and exert an indispensable influence in preventing lateral displacement of the patella during contraction of the quadriceps. It is these lowermost fibres of vastus medialis which atrophy so rapidly in affections of the knee joint such as acute synovitis. The ligamentum patellae is inserted into the tibia over the smooth, rounded part of the tubercle of the tibia—the part, that is, which is on the epiphysis. The area is limited above by an oblique groove which receives a very substantial portion of the ligamentum patellae (Hughes 1946). The infrapatellar bursa lies, not over the smooth part of the tubercle, but over the rough, pitted anterior surface of the head of the tibia immediately below the transverse ligament (Fig 6)

**Biceps femoris**—The tendon of biceps is not “split” by the lateral ligament of the knee joint. It wraps around the posterior part of the lateral ligament, the deep part of the tendon lies between the lateral ligament and the true capsule of the joint (between the long and short external lateral ligaments of old terminology). The superficial part of the tendon of biceps wraps around the superficial part of the cord-like long external lateral ligament, and it is attached to the lateral margin of the head of the fibula and sends an expansion across the superior tibio-fibular joint to the tibia.

**Popliteus**—From the rounded tendon of origin the fan-shaped muscle emerges beneath the arcuate ligament and diverges towards its insertion on the popliteal surface of the tibia. Although seldom described, it is true that a very substantial portion of this muscle arises not from the tendon of popliteus but from the arcuate ligament itself. Some of the uppermost fibres actually arise from the lateral meniscus, a fact which has been noted in very few texts

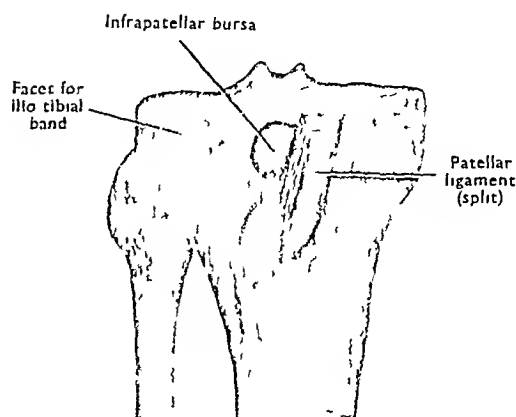


FIG 6  
Anterior aspect of the head of tibia

Moreover, the muscle fibres which truly leave the tendon and pass beneath the lower part of the arcuate ligament are firmly adherent thereto (Figs 1 and 3), their attachment to the arcuate ligament draws the muscle up in a sinuous manner which disappears when the arcuate ligament is itself dissected away. Consequently the true attachment of popliteus cannot be made out when the muscle is "cleaned" for a museum specimen.

*Protection of the lateral meniscus from injury*—It is suggested that the attachment of popliteus to the lateral meniscus (both directly, and indirectly by way of the arcuate ligament) is the primary factor in protecting the meniscus from injury. It is not the mobility *per se* of the lateral meniscus which makes it relatively immune from injury, but rather the *controlled* mobility gained by the ligaments of Humphry and Wrisberg and, especially, the popliteus muscle. In flexion of the knee joint a smaller surface of the femoral condyle articulates with the tibial plateau, consequently the menisci are not likely to be nipped between the articular surfaces during uncomplicated flexion. But in the flexed position, when lateral rotation of the femur on the tibia takes place (around the axis of the posterior cruciate ligament) the lateral femoral condyle glides posteriorly along the lateral articular surface of the tibia. It does not push the posterior arch of the lateral meniscus out of the way, the meniscus is actively pulled away by the popliteus muscle and by the pull of the ligaments of Humphry and Wrisberg. It is not the tendon of popliteus but the lateral meniscus which bevels the posterior margin of the lateral tibial condyle. The synovial membrane is prolonged from the joint as the popliteus bursa, which lies deep to the muscle, between it and the tibia. It often communicates with the superior tibio-fibular joint. Fixation of the posterior surface of the popliteus muscle to the arcuate ligament precludes the formation of any bursa on the superficial aspect of the muscle. It is possible that the primary origin of the muscle was from the fibula and that its ascent to the femur in man is a secondary event (Taylor and Bonney 1905).

**Soleus**—The tibial origin of soleus is usually stated to be the soleal line and the middle third of the medial border of the tibia. Actually the muscle has a much more generous origin. Only the strong aponeurosis on the deep surface of soleus arises from the soleal line. It will be seen that this line has two ridges—one above and one below. To the upper ridge is attached the popliteus fascia, derived from the semimembranosus tendon, to the lower ridge the aponeurosis on the deep surface of soleus is attached. The fleshy fibres of soleus arise from an area above the soleal line on the popliteus fascia (Fig 3).

**Ilio-tibial band**—As is well known the fascia lata attaches around the tibial condyles. Less generally appreciated is the fact that the ribbon-like condensation which constitutes the ilio-tibial band is received into a smooth non-pitted facet which stands out prominently on the front of the lateral tibial condyle. This facet marks the insertion, therefore, of three-quarters of the gluteus maximus muscle in addition to the tensor fasciae latae (Fig 6).

*Acknowledgment*—The author wishes to express his appreciation of the work of the Prosector to the Royal College of Surgeons D H Tompsett, Ph D who not only made many of the dissections (which will be incorporated into the Human Anatomy Section of the Museum) but also drew the illustrations.

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## 5 DYSCHONDROPLASIA

Synonyms—Ollier's disease, Multiple enchondromata

II A THOMAS FAIRBANK LONDON, ENGLAND

Dyschondroplasia is a somewhat rare developmental error characterised by rounded masses or columns of unossified cartilage in the metaphyses and diaphyses of certain bones. It was first described and named by Ollier in 1900. An admirable review of the subject was published in 1935 by Hunter and Wiles.

It is often linked with diaphyseal aclasis as pointed out in the section dealing with that affection, the two conditions being regarded as variants of the same fundamental developmental error. This may lead to confusion which is quite unnecessary though both result from a fault of the epiphyseal line, nests of cartilage becoming misplaced instead of being calcified and ossified in the normal manner, they are radiologically and in other ways quite different and in the vast majority of cases are readily distinguishable. In the condition to which the author prefers to confine the term dyschondroplasia, masses of cartilage are found inside the metaphyses, the lesions being essentially endosteal and not projections on the surface, as are exostoses.

*Hereditary and familial influences*—These influences play no part in the incidence of dyschondroplasia as they do so commonly in diaphyseal aclasis.

*Sex*—Both sexes are affected, males rather more frequently than females (Stocks and Barrington 1925).

*Age*—The diagnosis is usually made in childhood in exceptional cases the shortness of an affected limb may be noticed at birth.

*Etiology*—The cause is unknown it is said to act between the fourth and eighth months of foetal life (Speiser 1925) but there seems to be no doubt that in many cases it must have been active at a later date. Bentzon (1924) pointed out that the columns showed a tendency to radiate towards the epiphyseal line from the point of entry of the nutrient artery (*e.g.*, in the upper tibia) and he suggested that the cause might be hyperaemia due to anomalies of the vegetative nervous system. A number of experiments were carried out to prove this theory, but without convincing success.

*Distribution*—There is a strong tendency towards unilateral distribution of the lesions, though seldom strictly so. Enchondromata of one hand are commonly associated with a few enchondromata in the opposite hand, particularly in the thumb and little finger, with or without one or two in other bones. Enchondromata may, however, be confined to a single bone, or to some bones of a single limb. The two lower limbs only may be affected. In rare instances, all four limbs show fairly extensive changes. The bones chiefly involved are the long bones formed in cartilage and, as in the case of diaphyseal aclasis, it is at the more rapidly growing ends of these bones that the "lesions" are most often seen. The region of the knee joint and the lower ends of the radius and ulna are particularly common sites, but enchondromata are quite common at the upper ends of the femur and humerus respectively, and at the lower ends of the tibia and fibula. In the upper femur, columns of cartilage radiating from the lesser trochanter are not uncommon. As in so many developmental errors the region of the elbow joint is singularly free from changes. The long bones of the hands and feet, particularly the phalanges, are favourite sites for numerous enchondromata which are frequently the cause of obvious and disabling deformities. Dyschondroplasia



differs markedly in this respect from diaphyseal aclasis in which phalangeal exostoses are few and insignificant. The pelvis is a common site, the scapula rather less so. The ribs, sternum, and skull are seldom affected and the tarsus very seldom. The carpus and the spine usually escape, but the sacrum in one of our cases was affected on both sides, in addition to the ilium and pubis on one side. The middle part of the shaft of a long bone is seldom the site of lesions, when this does occur it is usually, but not exclusively, in the most severe cases. The occurrence of changes in the mid-shaft suggests that errors in development must have been active in foetal life.

**Clinical signs**—In typical cases the affected arm and leg are *dwarfed* to a varying degree, sometimes they are grossly dwarfed. In a youth of eighteen years the affected lower limb was ten inches shorter than the other. When one half of a metaphysis is occupied by columns of cartilage to a greater extent than the other, the rate of growth at the corresponding half of the epiphyseal line is often retarded. In this way *deformities* such as genu valgum may develop, in addition to general shortening of the affected limb. Deformity caused by large enchondromata in the phalanges is very common. In extreme cases a hand may be practically useless. As in diaphyseal aclasis, and certain other affections, the ulna frequently displays a greater degree of shortening than the radius. In these circumstances the shaft of the radius may be curved, and occasionally the radial head is dislocated. There may be cubitus varus at the elbow and inward displacement of the hand at the wrist. Seldom is the radius the shorter of the two bones. The fibula may be shorter than the tibia, without producing deformity of the latter bone. Facial asymmetry is sometimes present (Hunter and Wiles 1935). Involvement of cranial nerves, including the optic nerve, was reported by Nielson (1941). Fractures are distinctly uncommon except in severely affected phalanges. *Blood examination* reveals no abnormality.

**Radiographic appearances**—In the metaphyses, radiographic examination reveals cartilage-filled clear spaces of varying size and shape but with a marked tendency, except in the hands and feet, towards a columnar arrangement, the columns extending a varying distance into the shaft of the bone. The density of bone between cartilage columns is often increased, and these intervening bony septa may give rise to a striated or streaky appearance in the affected metaphysis. There seems to be no sufficient reason, however, for linking the condition of striated bones reported by Voorhoeve (1924) with dyschondroplasia and osteopoikilosis, as suggested by that author. The shaft of a major long bone, with the metaphyses at both ends severely affected, besides being unduly short is often thick and dense. Only rarely is the shaft of a major long bone extensively involved. In such a case the mottled, cyst-like changes may give rise to difficulty in diagnosis and call for biopsy, unless the hand or foot shows typical changes. An affected metaphysis may show little if any distortion of shape, but in well-marked cases some enlargement is usual and occasionally this is gross. Not infrequently there is curvature of the affected part of the bone, particularly when the cartilage columns are confined more or less to one side of the metaphysis. When a metaphysis is distended by large masses of cartilage these often protrude through the cortex. A breach in the cortex may also be caused by a relatively small column of cartilage. This may be seen not infrequently in a shaft, some distance from the epiphyseal line. If more than a nipple-like projection is formed, the gap in the cortex is often limited on one side by a sharp bony point which may be mistaken for an exostosis. Cortical projections formed in this way point towards the epiphyseal line, whereas true exostoses are always inclined in the opposite direction towards the centre of the shaft. Occasionally a small islet of cartilage is seen lying in the cortex of a long bone. The way in which normal growth and modelling of a metaphysis may cause protrusion of an enchondroma, which was originally completely endosteal and which has not materially increased in size, is well illustrated by Langenskiöld (1947). Though enchondromata and exostoses may be associated occasionally in the same case,

we believe that this combination is very rare indeed, and in fact much more rare than some authors would have us believe. In younger children the epiphyses usually show no abnormality but in older children, even from five years upwards according to Hunter and Wiles, irregularity in density with mottling and occasionally streaking of some epiphyses may be seen. In one of our cases, dense mottling of several epiphyses was a striking feature in films taken before the age of three years. These epiphyseal changes are not uncommonly confined to half an epiphysis, and are never seen unless the corresponding part of the metaphysis is the seat of definite changes. In the adult, abnormal streaking still visible in the shaft of a bone may be seen to extend into what was the epiphysis. In the digits, distension and loss of continuity of the cortex over one or more chondromata is very common, and the chondromata may occur anywhere in the shafts of these bones showing much less preference for the metaphyses and no tendency to a columnar arrangement. The commonest site in the pelvis is the ilium, near the crest, though chondromata may be seen in the pubis or ischium. The typical appearance in the ilium is that of clear columns radiating in a fan-like manner towards the crest. In two of our cases, both ilia were affected.

In older children and adolescents dense spots are seen scattered throughout an affected metaphysis, and even in the adjacent epiphysis or part of it. There is loss of definition of the cartilage columns and a general suggestion of ossification and healing, this transformation is usually well advanced by the time skeletal growth has ceased. According to Hunter and Wiles (1935) these changes are seldom seen till after six years of age. Dense spots found in a child of two and a half years (Figs 101-103) appeared at an exceptionally early age. Though such dense spots are found in enchondromata in the fingers, the tendency to arrested growth and to ossification is much less evident in these bones than in the major long bones.

**Progress and complications**—As a rule there is little tendency, except in the hand and foot, for the masses of misplaced cartilage to proliferate. In the fingers, the presence of many enchondromata of considerable size, fungating through the cortices, may eventually cause complete crippling of the hand. In a man of thirty-two years the total width of the fingers in a completely useless hand amounted to seven and a half inches. As already indicated, there is usually little tendency for the cartilage columns to calcify and ossify before adolescence is approached. In a major long bone proliferation of an endosteal nest of cartilage occasionally continues after growth has ceased, but this is very unusual. Even more rare is the development of a chondro-sarcoma. It is not always easy to determine whether such a growth has arisen endosteally, or started in the cartilage cap of an exostosis: the latter appears to be distinctly the more common of the two. The upper part of the humerus and the pelvis are sites at which chondro-sarcomata of apparently endosteal origin have been reported. Excessive enlargement of a mass of misplaced cartilage, except in the digits, is more common when the mass is solitary. Willis (1948) considered that a solitary chondroma, like a solitary exostosis or osteoma, should be regarded as a neoplasm and not as an isolated result of the developmental error we are discussing here.

**Pathology**—Histologically the masses consist of hyaline cartilage with cells of varying size, some abnormally enlarged, arranged in a somewhat irregular manner. There may be septa of fibrous tissue. Calcification and ossification of the cartilage may be seen, particularly in older patients. In the larger chondromata, signs of degeneration may be evident.

**Diagnosis**—Advice is usually sought because there is deformity. Radiographic examination then reveals the true nature of the case. The interpretation of radiographs of a single bone, particularly in adults, may be very difficult: the appearances may be misleading. But, when all the radiographic evidence is examined the diagnosis is usually easy. Films of the digits are particularly helpful in doubtful cases. In osteopoikilosis the dense spots in metaphyses and epiphyses which are a feature of the condition are not confined to two limbs, as is so often the case with dyschondroplasia, moreover in that condition, apart from the spots, the

bones are normal in density and outline Only occasionally is biopsy advisable Osteotomy for the correction of deformity, when it is called for, gives the surgeon an opportunity to confirm the diagnosis After osteotomy, the fragments unite readily

#### MAFFUCCI'S SYNDROME (1881)

This is a condition in which dyschondroplasia is associated with cavernous haemangiomata and phleboliths in the soft tissues Carleton *et al* (1942) gave an admirable review of the twenty cases published in the literature and reported two cases of their own In the first of these, a group of phleboliths was seen in relation to irregular enlargement of the anterior surface of one tibial shaft Except in this case, and one published by Krause (1944) in which all lesions were confined to one side of the body, the bone and soft tissue lesions seem to be entirely independent in their distribution

I wish to express my sincere thanks to colleagues and friends who have supplied me with details of cases under their care Some of the illustrations are reproduced by courtesy of the British Journal of Surgery

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## CASE 31—DYSCHONDROPLASIA—Both lower limbs

(Fig 94) Girl, aged four and a half years. Left leg bowed due to deformity of the femur, and all major long bones of the limb shorter than on the right. Arms and hands not affected. Enchondromata in the right ilium—very slight (and none at all in the left ilium) and at the ends of the femur, tibia, and fibula of both lower limbs, the changes being much more marked in the left. Though the distribution of lesions is unusual this case shows particularly well the columnar arrangement of changes in the metaphyses (Under Dr Donald Paterson)



FIG 94

Case 31. Lower limbs showing characteristic changes in the metaphyses. The tendency to columnar arrangement of the cartilaginous masses is well shown. Irregular density and mottling are seen in several epiphyses. Note that only the inner half of the epiphysis of the right femur is mottled and only the inner half of the metaphysis contains columns of cartilage.

bones are normal in density and outline. Only occasionally is biopsy advisable. Osteotomy for the correction of deformity, when it is called for, gives the surgeon an opportunity to confirm the diagnosis. After osteotomy, the fragments unite readily.

### MAFFUCCI'S SYNDROME (1881)

This is a condition in which dyschondroplasia is associated with cavernous haemangiomas and phleboliths in the soft tissues. Carleton *et al* (1942) gave an admirable review of the twenty cases published in the literature and reported two cases of their own. In the first of these, a group of phleboliths was seen in relation to irregular enlargement of the anterior surface of one tibial shaft. Except in this case, and one published by Krause (1944) in which all lesions were confined to one side of the body, the bone and soft tissue lesions seem to be entirely independent in their distribution.

I wish to express my sincere thanks to colleagues and friends who have supplied me with details of cases under their care. Some of the illustrations are reproduced by courtesy of the British Journal of Surgery.

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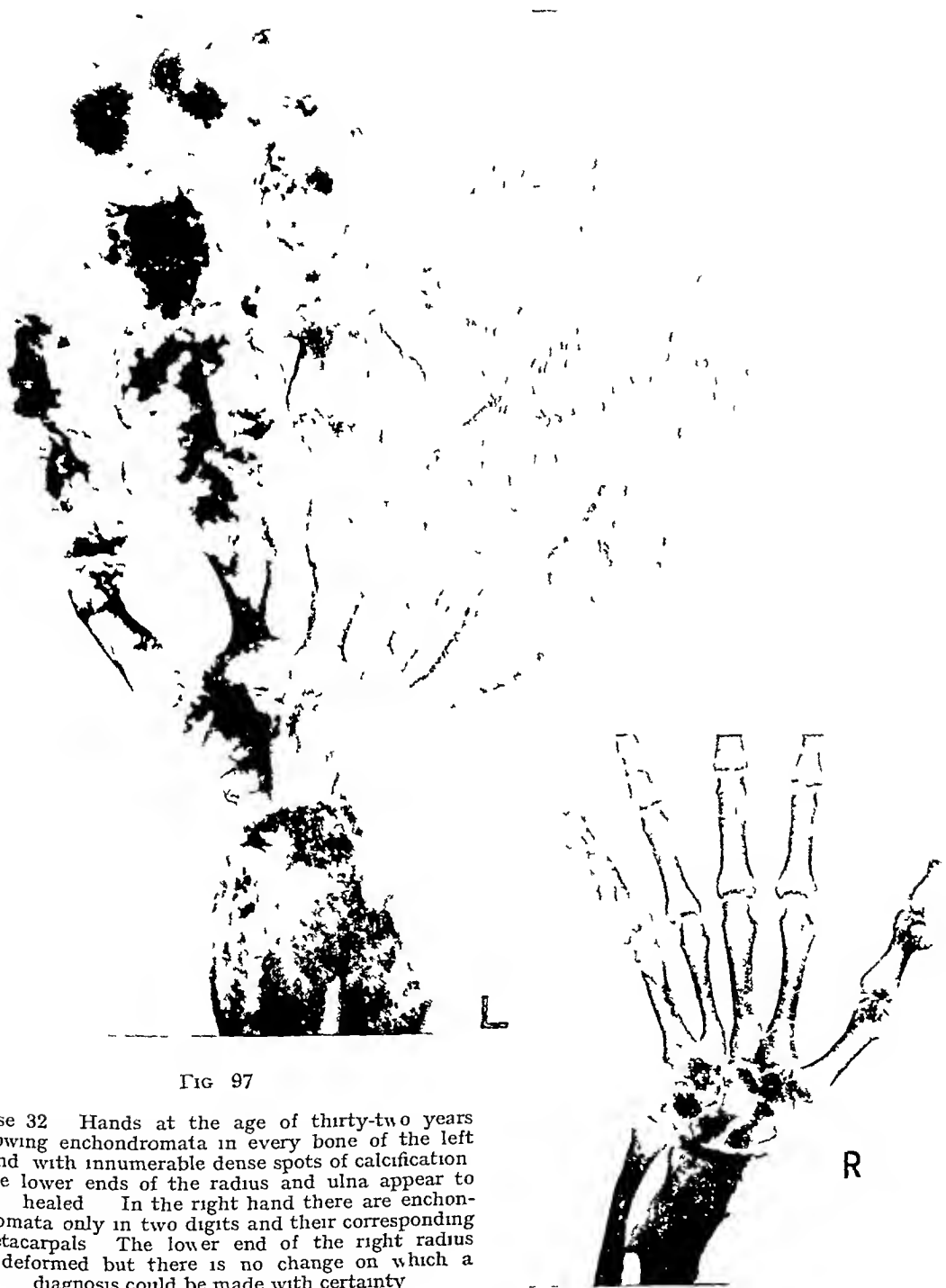


FIG 97

Case 32 Hands at the age of thirty-two years showing enchondromata in every bone of the left hand with innumerable dense spots of calcification. The lower ends of the radius and ulna appear to be healed. In the right hand there are enchondromata only in two digits and their corresponding metacarpals. The lower end of the right radius is deformed but there is no change on which a diagnosis could be made with certainty.



FIG 98

Case 32 Pelvis at the age of thirty-three years showing "healed" lesions in both ilia the left pubis and the left great trochanter

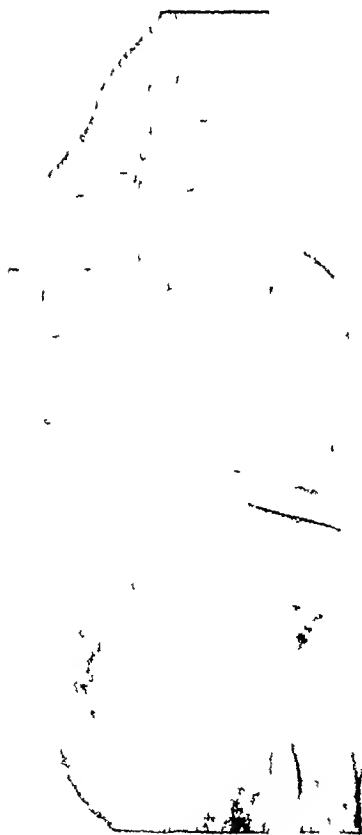


FIG 99



FIG 100

Case 32 Fig 99 shows the left knee at the age of thirty-three years there is great advance in ossification of the cartilage masses as compared with the film taken at the age of twelve years (Fig 96) Fig 100 shows the left ankle and foot at the age of thirty-three years, there are densely calcified spots in the lower ends of the tibia and fibula and in the phalanges The tarsus shows changes which are not characteristic of any particular dysplasia

**CASE 33—DYSCHONDROPLASIA—Bilateral to a greater degree than usual, all four limbs markedly affected**

(Figs 101-103) Girl One other child, a male, died of hydrocephalus at the age of three years First observed when seven months old Deformities have progressed steadily ever since, and are now gross at the age of two years and eight months (Under Mr R G Pulvertaft)



FIG 101

Case 33 Pelvis at the age of two years showing typical radiating columns of cartilage near the crests of both ilia, and enchondromata in both ischia right pubis and both femora





FIG 102

Case 33 Hands at the age of two and a half years, showing numerous typical enchondromata in both extremities to an approximately equal extent. The multiple dense centres of ossification in the cartilage at the lower ends of the right radius and both ulnae is most unusual at this early age and gives an appearance not altogether unlike that seen in dysplasia epiphysialis punctata. Note that the shafts of the radii and ulnae are short and stout the ulnae being as usual more shortened than the radii.

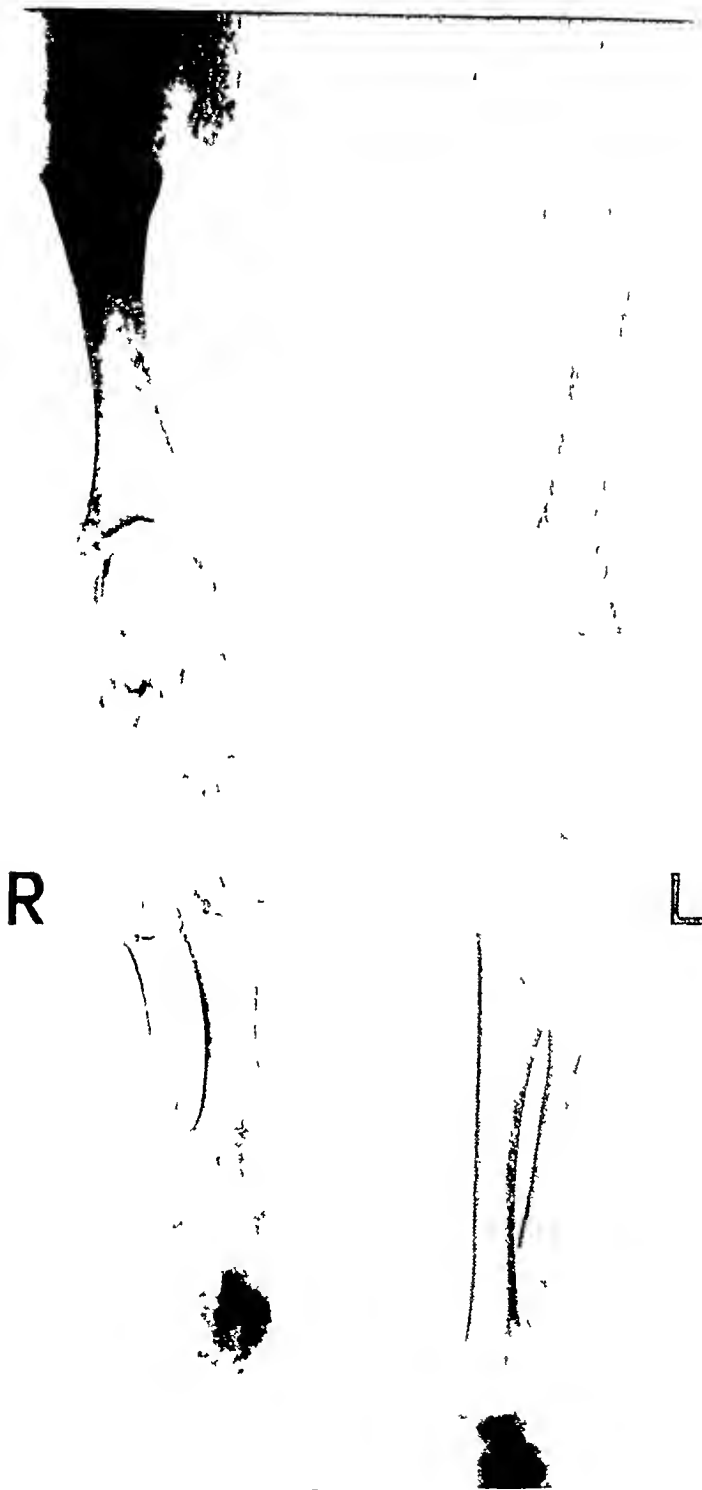


FIG 103

Case 33 Lower limbs at age of two years eight months showing all six major long bones affected with shortening of the right lower limb. Stippling with dense ossific centres of the epiphyses and adjacent metaphyses the latter largely cartilaginous is a striking feature and is a most unusual appearance at this early age. Similar stippling can be seen in the right tarsal bones. Note the spikes formed by the cortex at the lower end of the shaft of both femora. In left leg the fibula is more affected and much shorter than the tibia.

## CASE 34—DYSCHONDROPLASIA

(Figs 104-106) Male aged seventeen years Right arm and leg affected Gross interference with function of hand due to size and number of cartilaginous tumours Particularly severe deformity of the leg (Under Mr McCrae Aitken)



FIG 104

Case 34 Pelvis and femora, showing atypical changes in the shortened right femur The considerable involvement of the shaft and the texture of the bone, particularly of the lower metaphysis are unusual



FIG 105

Case 34 Right forearm and hand The metacarpals and phalanges show many enchondromata Those in the digits have proliferated to such an extent that one hand is hopelessly crippled The carpus as usual is free from cartilaginous masses The lower end of the radius shows a fairly typical appearance several dense spots are seen The ulna is surprisingly normal both in length and texture but there is a cartilage mass in the upper part of the lower third



FIG 106

Case 34 Lateral view of right knee leg and foot The grotesque deformity of the lower end of the femur is quite exceptional Looked at alone the diagnosis of this film would not be easy but the affection is clearly metaphyseal and the numerous dense spots well seen at the upper end of the tibia suggest a diagnosis of dyschondroplasia The curious outline seen at both ends of the tibia is probably not the result of fractures Note that the tarsal bones with the possible exception of the os calcis are unaffected

**CASE 35—DYSCHONDROPLASIA—  
Incompletely unilateral distribution**

(Fig 107) Male aged eighteen years Right arm and leg markedly short and deformed Never had osteotomy performed Right leg ten inches shorter than left, due partly to deformity of femur and tibia Unusual features were enchondromata in left pubis, as well as in both ends of left fibula, and *both* ends of the right ulna, with dislocation of the right radial head There were a few enchondromata in the left thumb and little finger and many in the right hand (Under Mr H H Langston)

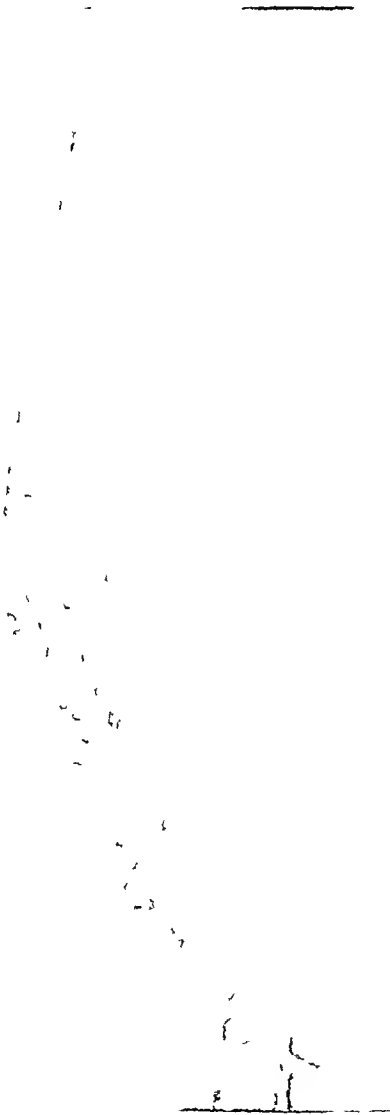


FIG 107

Case 35 Right forearm showing the shortening and deformity of the ulna and the dislocation of the head of the radius

**CASE 36—DYSCHONDROPLASIA—  
affecting left forearm only**

(Fig 108) Male aged nine years Noticed deformity for three years Recently complained that the arm pained him when working in the gymnasium The "lump" was said to be increasing in size Definite cubitus varus, with some prominence of the head of the radius Left forearm one inch shorter than the right Pronation limited by a quarter, supination free Bony prominence on the front of the lower third of ulna Humerus not shorter than right No exostoses felt on any bone No radiographic changes found except in this limb



FIG 108

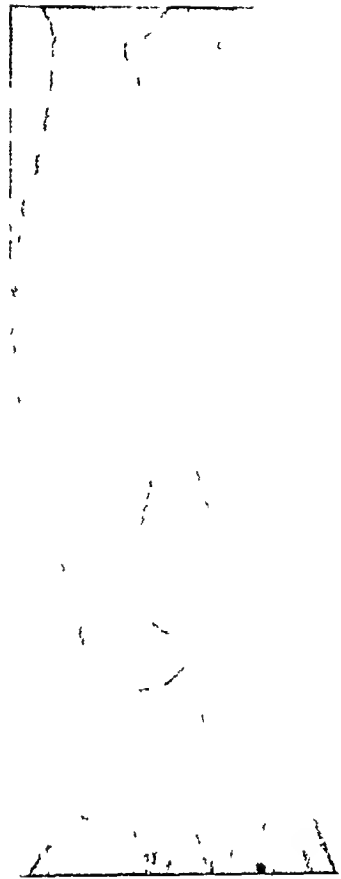
Case 36 Shortened ulna with curious appearance and spots of calcification in the clear area in the head of the bone Radius curved Typical enchondromata in third finger confirmed the diagnosis

### CASE 37—DYSCHONDROPLASIA— Unilateral case

(Fig 109) Boy aged eleven years. Left upper limb and left lower limb very short. Bones of both these limbs contain many enchondromata which are particularly numerous in the left hand. Sacrum and left pubis are clearly affected as well as the left ilium. Upper metaphysis of the left humerus, and both ends of the left femur, show extensive changes. Dense spots of calcification and ossification are present in many of the cartilaginous masses, they are particularly numerous and closely packed at the upper end of the humerus. (Under Mr L. W. Plowes.)

FIG 109

Case 37. Left forearm showing a typical column of cartilage in the deformed radius and fusiform enlargement at the lower end of the shortened ulna. Clear areas were also seen in the lower end of the humerus which is an uncommon site for enchondromata.



### CASE 38—DYSCHONDROPLASIA—Atypical case

(Figs 110–111) Male aged fourteen years. Progressive limp in the right leg had been noticed since the age of four years. Four fractures had occurred in the shaft of the right femur in the last six years. There was café-au-lait pigmentation over the upper dorsal and lower lumbar regions of the spine. Total shortening of the right lower limb was no more than half an inch but this was because gross shortening of the right femur was compensated by lengthening of the right tibia and fibula. Biopsy of the right tibia was followed by a pathological fracture and later by fusiform enlargement of the shaft of the bone. Microscopic section showed only cartilage cells. Blood examination revealed no important abnormality. Well-marked though very atypical changes were seen in the right femur and tibia. Lesions which, though atypical, might have been enchondromata were also seen in the upper half of the shaft of the left humerus, the lower end of the shaft of the right ulna, in some phalanges of both hands, in the right ilium near the crest, both fibulae, the trochanteric region of the left femur, and possibly in the shaft of the left tibia. There was one spot of irregular decalcification in the centre of the left parietal bone seen in the antero-posterior radiograph of the skull. The distribution of lesions in the lower limb was not metaphyseal, but biopsy suggests strongly that this case should be classified as dyschondroplasia. (Under Sir Harry Platt and Mr A. F. Bryson.)



FIG 110

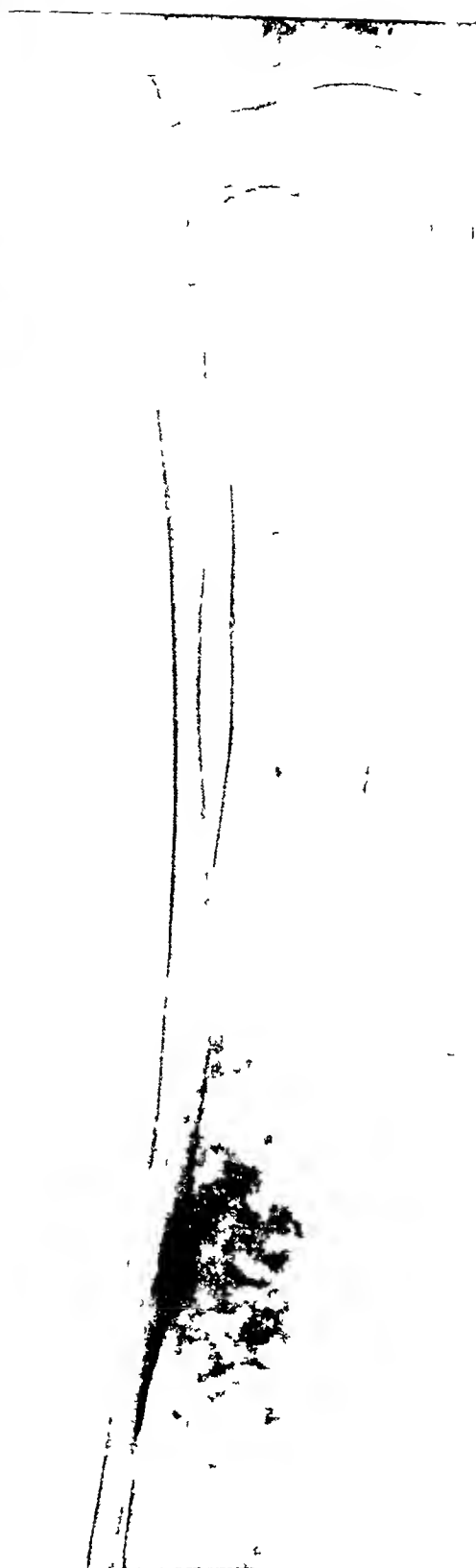


FIG 111

Case 38 The right femur (Fig 110) shows a curious mottled appearance in the lower two-thirds or more of the shaft and an old united fracture in the middle third of the shaft. The right leg (Fig 111) shows unusual changes affecting most of the shaft of the tibia with fusiform enlargement at the site of a pathological fracture which occurred after biopsy. Somewhat similar changes certainly not typical of dyschondroplasia are seen in the upper and middle parts of the shaft of the fibula.

## 6 METAPHYSEAL DYSOSTOSIS

In this excessively rare condition the metaphyses of all long bones consist for the most part of unossified cartilage. The radiographic appearances are unique and they differ considerably from those seen in dyschondroplasia.

In 1934 Mink Jansen of Leiden published a case. Seven years before he had presented a set of radiographs of the patient, who was then five years of age, to the Royal College of Surgeons of England. By courtesy of Sir Arthur Keith, formerly Conservator of the Hunterian Museum, the author was able to secure prints of all the films. Search of the literature has failed to disclose a single comparable case.

The patient was a boy, born with club feet which were treated by manipulation. The ankles, and the lower ends of the radii and ulnae, gradually thickened. The child crawled at six months, but he was unable to walk at three years. Eventually, however, he succeeded in walking with the help of splints. He was dwarfed, and at ten years of age was at least twelve inches below normal height. The lower limbs were more affected than the upper limbs, and they were markedly deformed. The feet were valgoid. The skull and spine were normal. Dentition was somewhat delayed. At five years there was some anaemia, and the serum calcium was high (16.6 mgm) but this gradually came down to 13 mgm per cent. Other investigations of the blood and urine were negative. At ten years further investigations revealed no abnormality. Jansen considered that the cause was abnormal intra-uterine pressure acting at a particular stage of foetal development, a theory which he postulated in the explanation of other developmental errors.

**Radiographic features**—The epiphyses have developed remarkably well, and are of normal density, but the metaphyses both at five years and ten years of age are "still cartilaginous and irregular, cloudy and impregnated with salts." Some of the epiphyses are displaced from the lines of the shafts. This is more obvious in films taken at the age of five years than later. The shafts of the long bones are stout, many are curved, and they end very irregularly with some expansion. There is a wide interval between shaft and epiphysis, the space containing a varying number of rather dense and discrete centres of ossification, especially close to the shaft. There is no suggestion of a columnar arrangement of the cartilaginous metaphyses as in dyschondroplasia, and the epiphyses are not mottled, either partly or wholly, as they may be in the allied condition. The spots of calcification and ossification in the metaphyses vary in size, shape, and density, and they are not quite like the circular dense spots which are seen in the "healing stage" of dyschondroplasia. Many of the metaphyses appear to be enlarged. Changes in the hands differ strikingly from those of dyschondroplasia, the cartilage masses, dotted with fragments of bone, are seen only adjacent to every epiphysis and they are not distributed irregularly as isolated enchondromata anywhere in the shafts of the metacarpals and phalanges. The carpus and much of the tarsus seem to be ossified normally, but the posterior part of the os calcis shows changes similar to those in a metaphysis. At the age of five years, but not at ten years, irregular or punctate ossification is seen in the navicular and cuneiforms. In the pelvis the anterior parts of the ilia are mottled, but there is no such mottling, as one might have expected, in the bone near the crests. The skull, spine, ribs, and clavicles appear to be ossified normally.

**Pathology**—A fragment from the lower end of one tibia, including portions of the shaft and the cartilaginous metaphysis, was examined histologically. The cartilage cells were either small and collected into nests, or large and "myxoedematous." Calcification was seen in the matrix. The junction of diaphysis and cartilage was irregular, and isolated masses of bone were seen in the substance of the cartilage, "as in rachitis."

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FIG 113

**Metaphyseal dysostosis**

Case 39 The boy at the age of ten years showing deformities of the lower limbs Fig 113 is a radiograph of the right shoulder joint and upper arm at the age of five years showing the unossified cartilaginous metaphyses at both ends of the stout humeral shaft, the mottled centres of ossification at the upper end and the well-ossified epiphyses at both ends Fig 112 shows the dwarfing, he was twelve inches below normal height

FIG 112

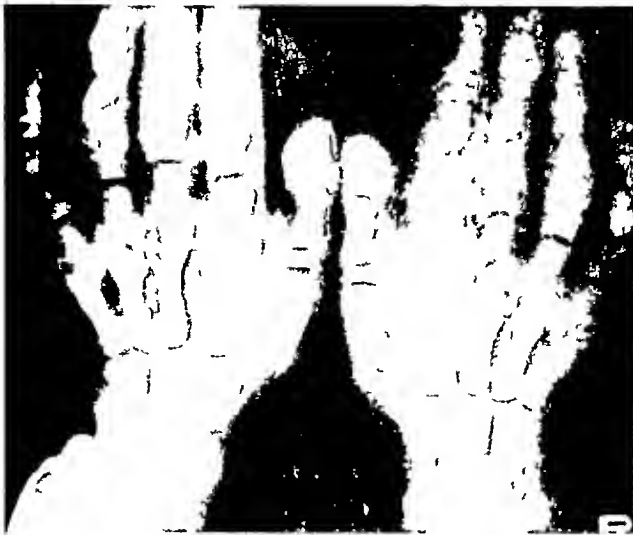


FIG 114

Case 39 Hands at the age of ten years showing the changes not scattered throughout the shafts as in dyschondroplasia but concentrated almost entirely in the metapophyses. Note that the carpal bones are unaffected.



FIG 115

Case 39 At the age of five years showing irregular ossification of the anterior part of the ilia and the acetabula, and the stout curved femora with expanded upper extremities and largely unossified necks.



FIG 116

Case 39 Ankles and feet at the age of ten years showing very irregular ossification and deformity of the lower metaphyses of tibiae and fibulae. Note well-formed epiphyses of these bones and irregular ossification of posterior part of the os calcis in both feet.



FIG 117

Case 39 Knees at the age of five years, showing the stout femora, the unossified metaphyses with mottled centres near the diaphyses and the well-ossified epiphyses of both the femora and tibiae. Note the displacement of the upper tibial epiphyses.

(Figs 112, 114 and 116 are taken from Dr Jansen's article.)





Agnes Hunt  
1867-1948

## Dame Agnes Hunt

Believing that a fortune might be made in Queensland by breeding Angora goats, Mrs Rowland Hunt, widow of the Shropshire squire whose estate lay in fertile plains between the villages of Baschurch and Ruyton-Eleven-Towns, gathered those of her eleven children who still accepted an imperious domination and arrived in Brisbane, exactly sixty-five years ago, intent on the purchase of a desert island. No desert island was for sale. No Angora goats were in Brisbane—indeed there were none throughout the length and breadth of Australia, but Mrs Hunt refused to believe it and said that if there were no goats there ought to be. She did, however, weaken in her resolve and compromised by purchasing a fifty-acre paddock in which to rear chickens. The stock was not good, and many chickens were born with crippling deformities, but Mrs Hunt was undaunted and when she decided to amputate limbs with a carving knife and replace them with peg-legs made of Bryant and May matches it was the duty of her youngest daughter Agnes to administer the anaesthetic.

Agnes was then aged sixteen. She had been bred in a school of hard and rigid discipline. Her mother disliked children—"disliked them when they were coming, during their arrival, and most intensely after they had arrived." Her father "laughed immoderately at any accident." Her brothers induced a robust spirit of fearlessness, and the only governess who served the family with efficiency gave notice because the children "were allowed to kill themselves in too many different ways." When Agnes was aged ten she developed septicaemia and infective arthritis of the hip joint with high fever, sinus formation, and rapid destruction and dislocation of the joint, but within nine months her bath chair was harnessed to a pony which was raced until the chair was overturned, and within twelve months she was playing ice-hockey—on a home-made sledge, keeping goal. In later years she wrote of her mother "Her psychology of childhood amounted almost to a crime but her treatment of me as a cripple was beyond praise. I was never allowed to pity myself or consider myself different. My brothers and sisters were never made to fetch and carry for me, and I joined in their play." It is true that at this age Agnes Hunt began her "apprenticeship to crippledom and the great education of pain", she was destined to limp her way through life with stick or crutch, but already she had learned a first principle—the joy of life despite disability—and this was to be her great contribution to medicine.

When Mrs Hunt decided that the Austrahan continent had failed to live up to expectation, Agnes knew that "you might as well try to stop Niagara as stop my mother when once she had made up her mind." But a proud spirit of determination in the mother had been inherited by the daughter and, when Mrs Hunt decided to return to England, Agnes Hunt decided to stay in Tasmania to look after her brother Tom. She was influenced in this decision by an accident sustained by a young man who was felling trees. "In splitting a big tree, one of the wedges slipped and the great trunk closed over his hand, holding him fast. The poor lad's axe was just out of reach. He was found dead two months later and from the marks on his wrist he had tried to gnaw his hand off. I decided to stop."

In 1887, at the age of twenty, having received three proposals of marriage in one day—"not very eligible ones" she wrote "but still rather a record," she left the Tasmanian ranch and returned home with her brother. Training as a nurse began as lady-pupil at the Royal Alexandra Hospital in Rhyl, North Wales, and the West London Hospital, Hammersmith. Her one and only term of night duty was devoted to a midnight game of catch-as-catch-can round the wardroom table, chased by an epileptic madman who threw inkpots at her while she threw jugs of water at him. At that time nurses lived in primitive conditions and engaged in astonishingly long hours of duty, the evening meal consisted of bread, cheese, and beer.

The life was hard and arduous, and was indeed a sacrifice. So impressed was this young girl with the adverse conditions under which nurses served that she made a vow "If ever I rise to be Matron, no girl shall ever be the worse in health because of her work among the sick. This vow I kept." This vow, Dame Agnes Hunt, you did indeed keep. To-day, in the Robert Jones and Agnes Hunt Orthopaedic Hospital the prowess of a nurse in the hockey field is almost as important as her skill in the operating theatre. Never was a staff of girls more able, more happy, and more ready to give of their best.

It was in Rhyl, on the sea-coast of North Wales, that two fundamental principles of the nursing of chronic illness were learned—open air and happiness. The Royal Alexandra Hospital was perhaps the first hospital for cripples ever to advocate fresh air as an integral part of treatment, and it was the teaching of Miss Graham, one of the founders, that "no nurse is worth her salt if she has not the joy of life within her and the power of sharing it with her patients." In due course Agnes Hunt qualified. She was awarded the Queen's badge and brassard, and spent a year in Northamptonshire nursing a typhoid epidemic. After resting in bed for six months on the instruction of a heart specialist she engaged once more as a district nurse in treating five hundred victims of a smallpox epidemic.

In 1900 "mother broke it to me that she was becoming old and deaf and intended to live with me. This was rather a blow." It was a blow because at first it appeared that the daughter's career of nursing might be ended, there could be no more travel and there could be no more responsibility as a district nurse. But, on reflection, this indomitable girl realised that it might still be possible to live at home and yet to nurse—and thus began the story of Baschurch, the pioneer convalescent home from which developed and spread throughout Great Britain and the world the ideals of country orthopaedic hospitals, after-care clinics, preventive treatment, and resettlement of the disabled. Now, in 1948, the vast resources of the Ministry of Health and the Ministry of Labour are engaged in the treatment and resettlement of nearly one million disabled persons. Orthopaedic hospitals and after-care clinics have been established throughout the country. Hundreds of orthopaedic surgeons and thousands of orthopaedic nurses, physiotherapists, almoners, and resettlement officers are solving the problems of the crippled and the disabled. But what was the beginning? The beginning was "mother intended to live with me." A small and broken-down country house with an estate of no more than three-quarters of an acre was adapted. The drainage was primitive, the garden was so run-rut that it was a jungle and became known as the lion's den, there were a few cowsheds with broken walls and leaking roofs—this was the Baschurch Convalescent Home. Very soon the accommodation was unequal to the demand and stables and cowsheds were used for sleeping quarters. The sheds were more damp and draughty within than without, so that open-air treatment was quickly enforced. The lesson had been learned in Rhyl—open air and happiness. Open air was inevitable. Happiness may be judged from the pages of "Ye Olde Baschurch Cripples' Journal," produced in 1905 by two cripples and illustrated in colour by Mrs Rowland Hunt. The total circulation was two handwritten copies. An editorial, signed by Brother Aaron, reads

What causes the most excitement is the picnics. We put the cripples on drays with springs and the others on wagonettes. When we have reached the spot planned, the horses are taken out and fastened to the trees and all the cripples who can't get about are put on rugs. Then we get sticks and put the kettle to boil and tea is ready in no time. We have a good game of something such as rounders. Those on crutches play as well but they are far more artful for when they are about a yard off the base they suddenly drop, of course the crutches reach it if they don't and they are let stand up as if they got there by fair means. All sing until they have hardly any breath left to sing the National Anthem. The people in the cottages all come out and by the look on their faces we could almost believe they wished to be ill just for the sake of the picnics."

There were picnics to the country and picnics to the seaside. The famous pony, Bobby, "the dearest and wickedest of ponies," made history for himself when he was so often left in sole charge of a cargo of cripples. Sir Frederick Kenyon recorded an incident in verse. Motor cars had recently been introduced, the roads of Shropshire were narrow, and the

Baschurch Home was out for a picnic as usual Bobby met Jonathan Hustler's new car with its rush and hoot and roar

Bobby thought this is something new something very unpleasant too! It may be right but I don't quite know so back to home I am going to go Round he turned with his precious load and off he set in the middle of the road The road was narrow the road was long Jonathan's language grew very strong He hooted, he tooted, he shouted he swore Bobby went steadily on before The neighbours laughed to see the sight Bobby looked neither to left nor to right till the dray and the whole of its cripple crew safely back to the home he drew When Jonathan started out that day he swore that nothing should bar his way though police traps in every hedge were hid no Bobby should stop him But Bobby did

Three years later, recurrence of infection in the hip joint made it necessary for Sister Hunt to consult Robert Jones in Liverpool For some months thereafter she was immobilised on a Jones' abduction frame "Immobilised" is perhaps hardly the term to use in relation to Agnes Hunt even when she was secured on a spinal frame with its bars, bandages, and traction tapes "One day," she wrote "soon after I had returned from the Royal Southern Hospital and was still on a frame, I drove the black cob in the dray to Shrewsbury to do my Christmas shopping I had several cripples with me, one of whom was disabled only in the arm and could climb on and off the vehicle to ask the shopkeepers to come out As luck would have it the cob was restive and a new bobby came up and asked 'Who is in charge of this horse?' With all the dignity I could muster I replied haughtily that I was A frame is not an instrument that adds to one's dignity and the bobby's only answer was that he considered it unsafe and must take my name and address I told him, and thinking to impress him added that I used to live at Boreatton Park Unfortunately he knew this place only as a private lunatic asylum, my brother had let the house for that purpose some time after my father's death The policeman remarked acidly that it was just the sort of place he would have expected me to come from"

This association with Robert Jones was a milestone by which the Baschurch Convalescent Home became an orthopaedic hospital McCrae Aitken was at that time house surgeon at the Royal Southern Hospital, Liverpool, and he wrote "There arrived from time to time in the out-patient clinic a woman, an outside porter from the railway station, and a home-made handcart like a baker's tray on perambulator wheels The cart contained crippled children, perhaps as many as eight, in various forms of splints The woman was Miss Hunt of Baschurch A return train had to be caught so the party was soon inspected Those requiring operative treatment were admitted, cases left at a previous visit were put on the handcart, it was as simple as changing books at the library" The outside porter was employed on arrival at Merseyside because this was so much cheaper than bringing an assistant from Baschurch Even the perambulator wheels were of significance The railway ticket for a child's perambulator cost only one shilling, the ticket for a handcart was much more expensive, and it needed only the good-humoured domination of Miss Hunt to persuade railway officials that this unusual form of transport was indeed a perambulator

As work increased, Robert Jones himself went to Baschurch and operating lists were performed every month on the kitchen table Doctor Urwick of Shrewsbury accepted the responsibilities of medical superintendent More and more beds became available and the facilities were steadily improved After the 1914-18 war a hutted Army hospital was taken over Many original huts still remain and the private wing, known facetiously as Harley Street, consists still of the horse-boxes which were unwanted after the first war Staff was gathered and the talent of Alwyn Smith, Girdlestone, Naughton Dunn, McCrae Aitken, and many other distinguished contemporary surgeons, made it certain that the Baschurch Convalescent Home should serve the county and become the Shropshire Orthopaedic Hospital, and in due course should serve the whole country and become the Robert Jones and Agnes Hunt Orthopaedic Hospital Gradually, the hospital was rebuilt in accordance with Agnes Hunt's ideals "I can see in my mind's eye a hospital with its long, low, one-storied wards and big French windows opening out on to lovely lawns, flowers, and big spreading trees



Is this dream impossible? " It was not impossible, John Menzies saw to that. He was the man who was "found" by Sister Hunt, was inspired by her, and for so many years has served and is still serving faithfully as Secretary-Superintendent. Under his direction new open-air wards were built, the gardens, lawns, and trees which were imagined by Miss Hunt became a reality, and the laboratory facilities, X-ray equipment, and operating theatres which are essential features of a modern hospital became available. Consultants visit from Liverpool, Manchester, Birmingham, Cardiff, and London. The resident staff includes surgeons from England, Scotland, Ireland, Wales, Australia, Canada, South Africa, and the United States of America.

A short visit to this hospital may convey the same impression as a visit to any other important country orthopaedic hospital. Was this the contribution of Agnes Hunt? It was one of them, but it was perhaps the least. As early as 1907 it had become obvious that extensive accommodation and excellent facilities in the central hospital did not solve the problems of preventive treatment and follow-up supervision. Many families had spent their lives in the wilds of Blaenau Ffestiniog, or some remote hamlet, with a geographical horizon limited to a twenty miles' radius. Were they to be expected to travel with a crippled child to Shropshire, a journey which seemed as venturesome as one of the explorations of Columbus? And if initial fear was overcome, and the child was admitted to hospital, could the week-by-week supervision of after-treatment be continued over many months and years when every hospital visit called for one day's travel in each direction? It was not enough for the patient to go to the hospital, the hospital must go to the patient. And so a system of after-care clinics was established—a plan which may now appear obvious but which at that time called for vision, enterprise, and a complicated organisation. The first after-care centre was established in Shrewsbury, and as the influence of the hospital widened so were its outposts created. To-day, in an area which includes many counties, and covers hundreds of miles of rural and sometimes densely populated country, there are thirty-six after-care centres visited daily or weekly by orthopaedic nurses, physiotherapists, and social service workers, and at less frequent intervals by orthopaedic surgeons from the parent hospital.

In this activity Agnes Hunt was responsible for the development of a vast scheme of voluntary service which might well be recalled in this day of State direction and centrally planned health service. Every clinic is served by a County Voluntary Orthopaedic Association. Hundreds of women, previously untrained as nurses but quickly acquiring sufficient knowledge to recognise early cases, using their influence to ensure that such cases were brought within the ambit of the centre and thus applying themselves to the important tasks of preventive treatment, learning to carry out the instructions of orthopaedic nurses and orthopaedic surgeons, giving encouragement and moral support to cripples and their parents during long months and years of treatment, have devoted their lives and given whole-time service, five days a week throughout the last thirty years. They were inspired by Agnes Hunt because she worked with them, she herself attended the clinics and was one of them. Let us hope and believe that this spirit of devotion which has been maintained for a full generation will not be dispelled, or even dimmed, by the reforms of hasty planning.

It was in 1927 that Sister Hunt succumbed to the stimulation of Robert Jones and agreed that the problem was not yet solved. It was not enough to search out cripples and arrange hospital and after-care treatment. Crippled adolescents must be taught not only the joys of normal recreation but also the responsibilities of normal work. A retraining scheme was necessary. She wrote "I collected four boys, already training in the boot and blacksmith's shops, and two girls from the splint-making department, and solemnly informed them that they were 'The Shropshire Orthopaedic Training School for Cripples'. They were suitably impressed but were anxious to know what happened next. As this was more than I could tell them the meeting adjourned." Miss Hunt decided to write to the County Councils and Poor Law Guardians and "offer this splendid opportunity of making their cripples self-

supporting " The replies flabbergasted her " Before you could say ' knife ' we had one hundred and fifty names on the waiting list and not even a hut to put them in Where were they to be housed and fed? What trades would be suitable? What about instruction? How would the hospital committee take this new venture? And where on earth would the money come from? " As usual, enthusiasm came first, but accomplishment came next With Miss Sankey, who is well remembered as a superb After-care Superintendent, Miss Hunt moved into the Derwen which was to become the Cripples' Training College There was an early stage when after being granted £50 by the Committee " we also annexed some unconsidered trifles from the hospital " In the next stage Miss Hunt tried to work out the cost of surgical boots and wrote " Ten shillings for leather and two days of man's time at three pounds ten shillings a week plus 5 per cent profit equals —? Eventually I put a which I had been told meant an unknown quantity, and went dismally to bed " Mathematics and financial acumen were not her strong points but, within a year, Mr Rhaiadr Jones and his wife were appointed Manager and Matron, and thereby the Cripples' Training School gained the services of a first-class financier and a devoted woman who have applied themselves to this task ever since A college was established for the training of crippled children, of whom no less than 90 per cent have made their own livings

Twenty years later the Disabled Persons' Employment Act was passed by the Government of this country, and the Disabled Persons' Corporation was established Of the one million disabled who are now registered in Great Britain a high proportion have been trained to take their place in the open labour market and proved themselves to be no less efficient than their able-bodied colleagues Those few whose disabilities were so grave that they could not have been expected to compete in the open market have been engaged in the sheltered factories of the Disabled Persons' Corporation, the trade name of which is " Remploy " At the same time voluntary effort has continued at the St Loyes' College for Training and Rehabilitation of the Disabled, Exeter, the Queen Elizabeth's Training College for the Disabled, Leatherhead, the Heritage Crafts' School, Chailey, the Lord Roberts' Memorial Workshops, the John Groome's Crippleage, the Robert Jones' Workshops, the Papworth and Enham Village Settlements, the St Dunstan's Institutes for the Blind, the National Institute for the Deaf, and the Duchess of Portland's Training College for the Disabled, Nottingham Little did those four boys and two girls realise, when they were appointed solemnly as a Training School for Cripples, that they were to be forerunners of a great reform in resettlement of the disabled of which Great Britain is now proud

Agnes Hunt, the " Florence Nightingale of orthopaedic nursing," who received the Royal Red Cross in 1918, and was created a Dame of the British Empire in 1926—the highest honour which can be awarded to any woman in this country—was responsible for important advances in preventive treatment, the creation of an orthopaedic hospital, the organisation of an after-care system, and the development of a Cripples' Training College In recent years she asked herself to name the essential qualities of a nurse and replied " Common sense, gentleness, kindness, and the power of giving hope and joy to those who are suffering " In these words she linked herself with those who are ageless, for was it not Galen who wrote " Confidence and hope do more good than physic He cures most in whom most are confident " ? Most were confident in Agnes Hunt At the early age of eleven she learned to enjoy life despite disability, at the age of eighty-one she died as she had always been—cheerful, brave, courageous, indomitable She proved by example rather than by precept, and the decision of history may well be that the greatest of all her contributions was her own life

REGINALD WATSON-JONES

The quotations in this appreciation are from ' This is my Life ' by Agnes Hunt (Blackie & Sons Ltd London 1938) and ' The Story of Baschurch ' (Caxton Press Oswestry) I am also grateful to Mr Rhaiadr Jones for access to many unpublished documents The colour print of Dame Agnes Hunt has been reproduced by kind permission of the Derwen Cripples' Training College Oswestry

# THE ART OF OSTEOGRAPHY

WILLIAM BROCKBANK and D LL GRIFFITHS, MANCHESTER, ENGLAND

*From the Medical Library of the University of Manchester*

The early development of orthopaedic surgery and of the science of human anatomy ran hand-in-hand. Anatomists were surgeons. The surgery of the body-cavities was impossible, so that one may claim fairly that anatomists founded their science as part of the development of limb surgery and the surgery of the body wall, though, naturally, their attention was also focused at an early stage on the anatomy of the viscera.

In days when dissections were rare, illustrations of anatomical detail were peculiarly important. Skeletons could be acquired only with much difficulty and with no little risk. Vesalius acquired one skeleton by removing a body from the gallows. The work of the artist was an important medium in the spread of anatomical knowledge. These early illustrations are of interest to-day. Many are of great artistic value, and it is interesting to note how many artists saw the skeleton as a living structure, to be depicted in attitudes of action. Certainly they did not regard the skeleton as a series of "dry bones" as have many of their successors.

Anatomical illustration came into its own in 1543 with the publication of *De Humani Corporis Fabrica* by Andreas Vesalius (1514–1564), a surgeon who at the age of twenty-three years became Professor of Surgery and of Anatomy at the University of Padua. The *Fabrica*, which first discarded the Galenical tradition by describing human and not animal anatomy, is one of the most important works in the history of medicine. It was illustrated by Titian's pupil Jan Stephen Kalkar, the first artist to produce anatomical pictures which combined beauty with reasonable accuracy. Vesalius supervised his illustrator's work with great care and sometimes complained of the time and trouble which had been consumed. The pictures were made chiefly from dissections of strong and youthful bodies, they were printed from clear wood engravings (Fig 5).

In 1685 Godfried Bidloo (1649–1713) of Amsterdam published his great *Anatomica Corporis Humani* with engravings from drawings made by Gerard de Laresse. These are adorned with many accessories in design in the well-known style of Laresse, but the figures show that the artist lacked expert guidance. This can be seen clearly in the skeleton shown in Fig 6, which does not show natural proportions and is heavy and lacking in beauty. It is not known who made the engravings but they are most elegantly done. Bidloo worked on his book for nine years and on the strength of it was appointed to the Chair of Anatomy at Leyden in 1694. Later he became Court Physician to William III, and he accompanied that monarch to England.

These plates had an interesting history. In 1698 William Cowper (1666–1709) published in Oxford his *Anatomy of Human Bodies*, including in it one hundred and five of Bidloo's plates, so that his work was original only in the text which was admirable, and in nine other plates supplied by Cowper himself. Cowper's publishers had apparently bought three hundred copies of each plate from Bidloo's publishers without Bidloo's knowledge or consent. Although Cowper praised the artist in his introduction, his only reference to the man who made the dissections was to say that the plates "were sometime published by Dr Bidloo." Bidloo was annoyed and upbraided him in a publication *Gulielmus Cowper criminis literaris citatus* (1700). Nevertheless it cannot be denied that Cowper's was much the better book.

William Cheselden (1688–1752) was the outstanding surgeon of the first half of the eighteenth century. He was a popular figure, with a wide circle of distinguished friends. He enjoyed life. He was a keen follower of prize-fighting. He was a racy and a witty talker. But above all he was an amazingly skilful surgeon. He was one of the earliest surgeons to dissect publicly at his own house the bodies of criminals, and in so doing to earn the displeasure of the Barber Surgeons' Company, for his lectures coincided with theirs and were more popular. He became remarkably adept at the operation of lateral lithotomy, frequently performing it in one minute—his record being fifty-four seconds—a feat which was of great importance in days when there was no anaesthesia. His mortality of 17 per cent was not unduly high.



FIG 1

Andreas Vesalius (Brussels 1514-1564) from a painting by  
Tintoretto—from Wegner



FIG 2

Godfried Bidloo (Amsterdam, 1649-1713) from his *Anatomica  
Corporis Humani*



FIG 3

William Cheselden (London 1688-1752) from Wegner



FIG 4

Bernard Siegfried Albinus (Leyden, 1697-1770) from Pettigrew

HUMANI FABRICA LIBER I 205  
 CORPORIS HUMANI OSSA,  
 POSTERIORI FACIE PROPOSITA.

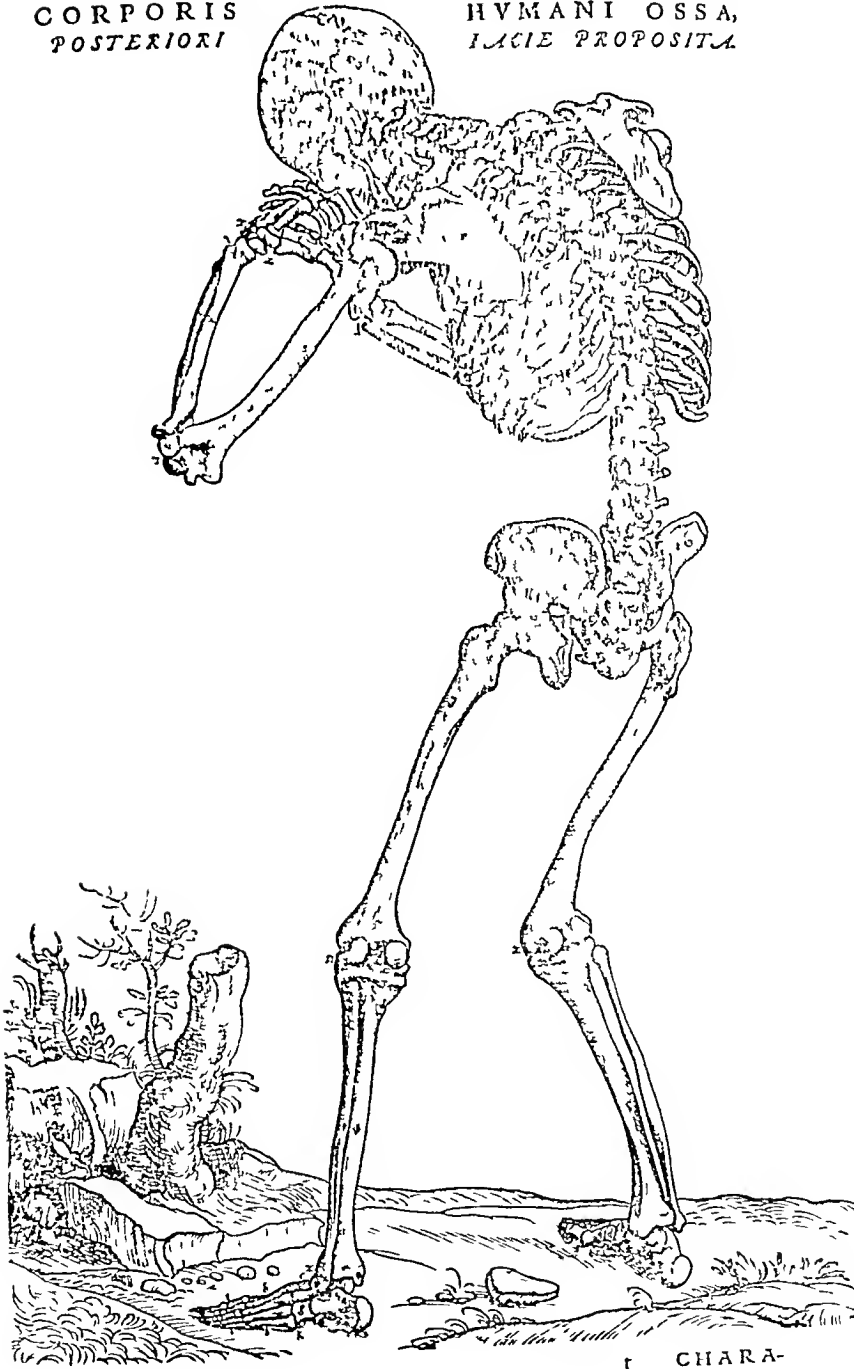


FIG 5

From Vesalius *De Humani Corporis Fabrica*

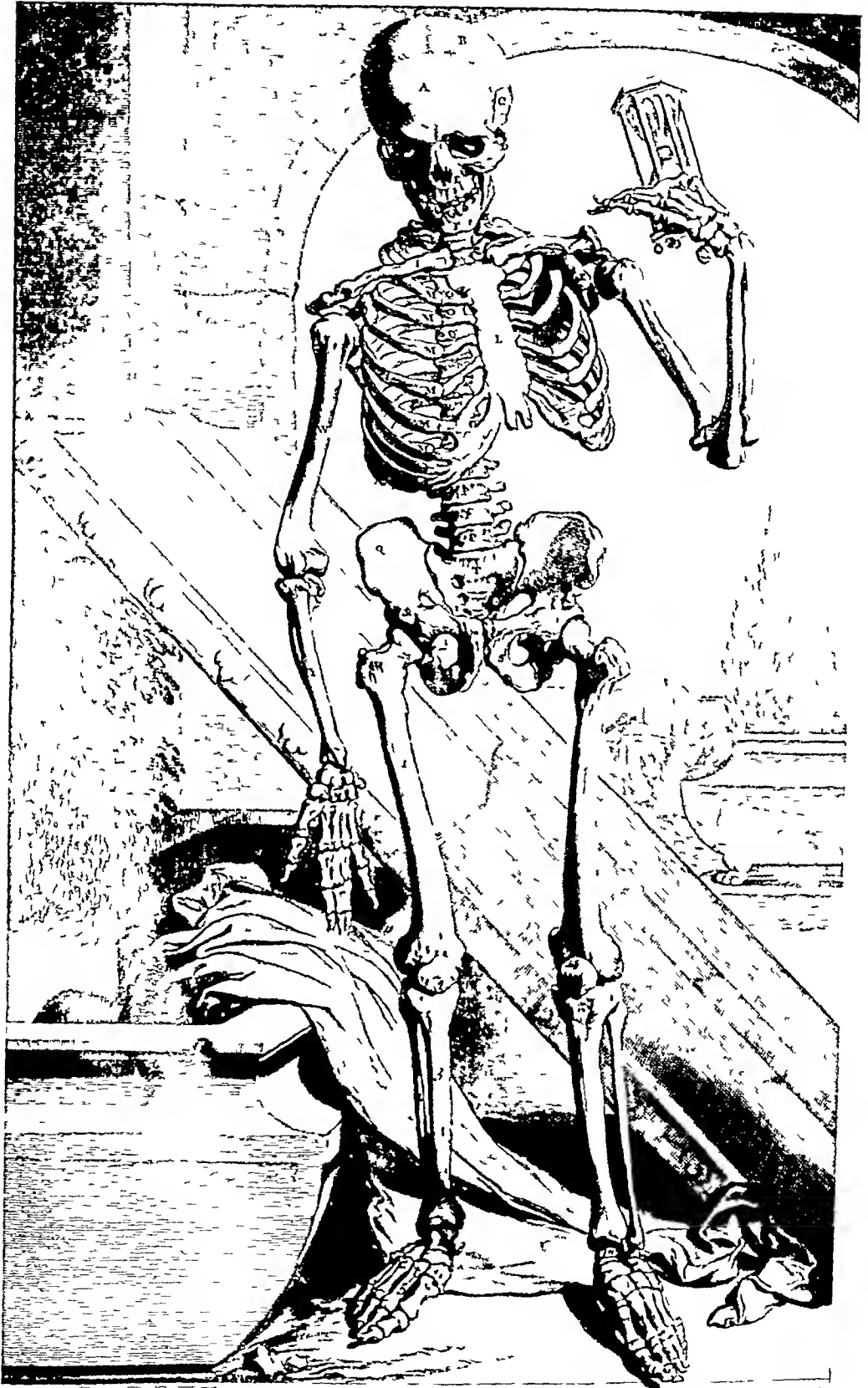


FIG 6

From Bidloo *Anatomica Corporis Humani*

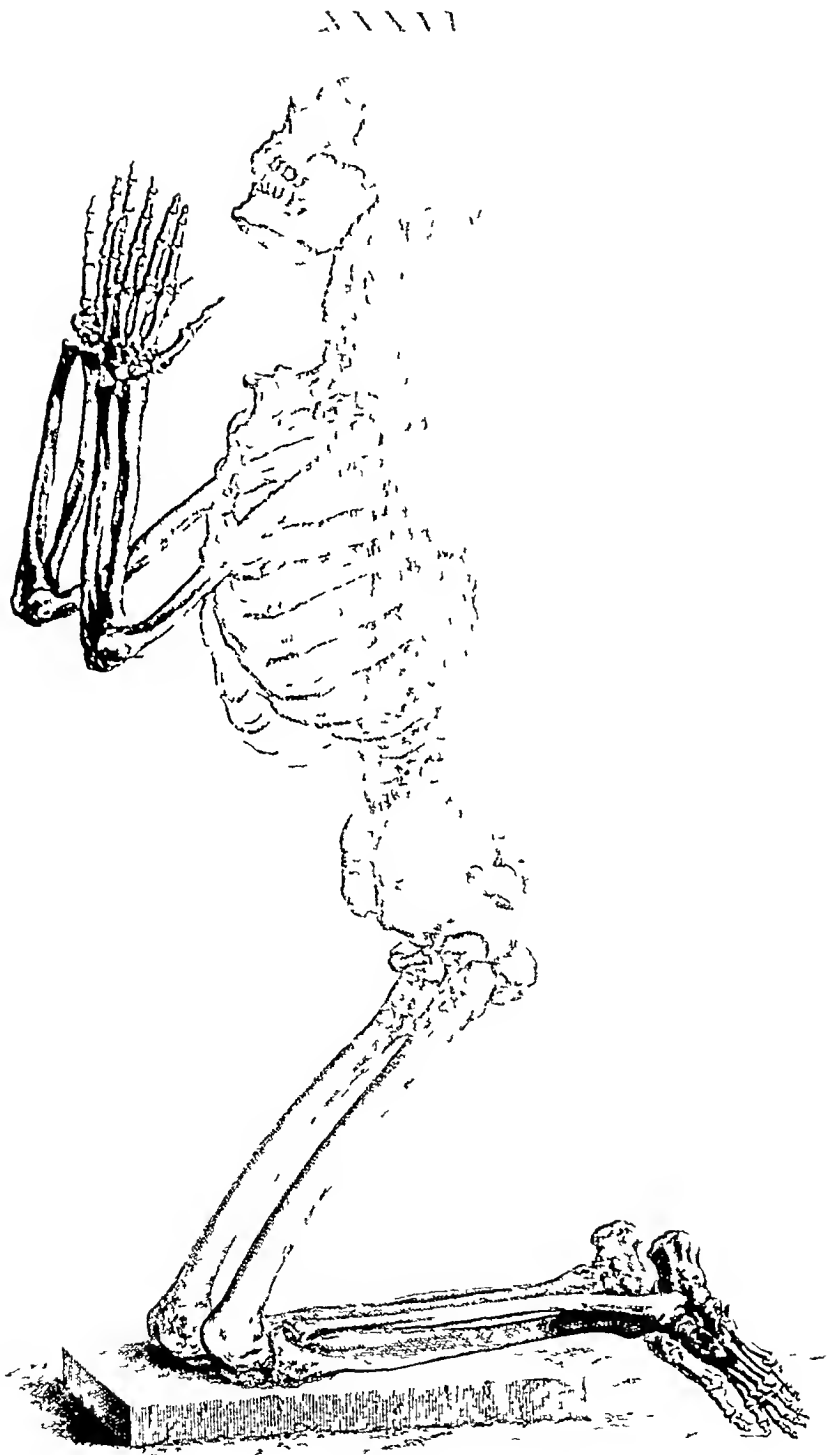


FIG 7

From Cheselden *Osteographia*



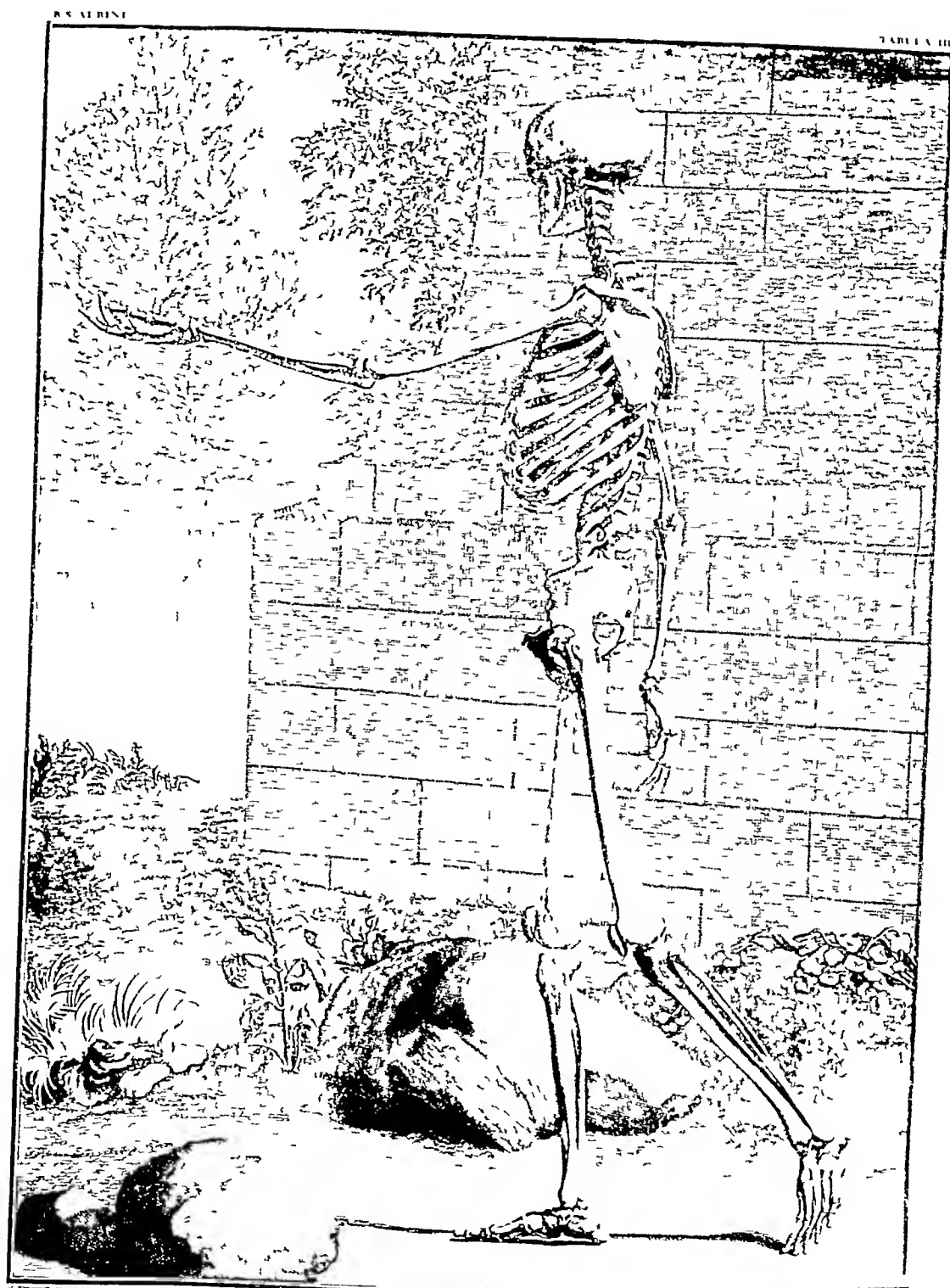


FIG 8

From Albinus *Tabulae Skeleti et Musculorum Corporis Humani*

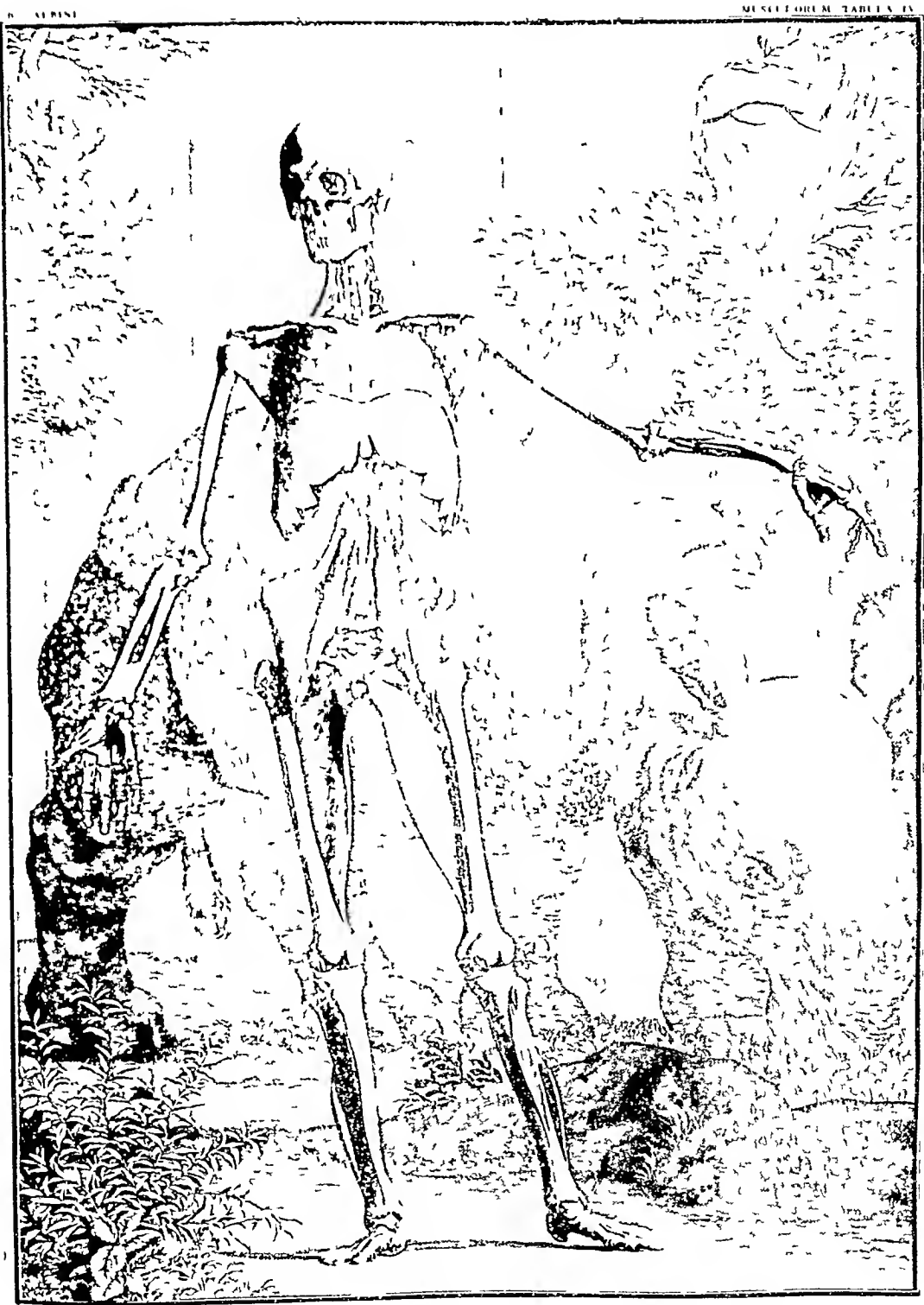


FIG 9

From Albinus *Tabulae Skeleti et Musculorum Corporis Humani*

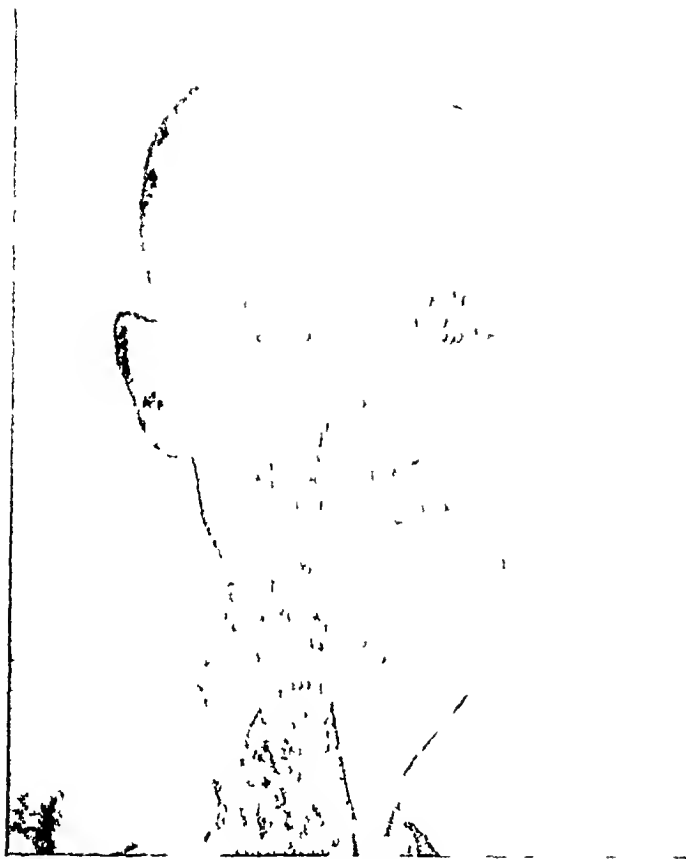
He wrote several books, the most interesting of which was his *Osteographia* published in 1733. It was dedicated to Queen Caroline and included full and accurate descriptions of human osteology with a fine series of fifty-six engravings, mostly of individual bones (Fig 7). These were probably drawn with the camera obscura and the title page shows Cheselden making a drawing by this method. Not only does this book reveal the normal anatomy of bones, it shows something of bone disease, and is one of the finest of English works with anatomic illustrations. It also includes an engaging series of illustrations of the skeletons of animals, birds and fishes.

Bernard Siegfried Albinus (1697–1770) was the son of an eminent physician and professor of anatomy at the University of Leyden. He studied in that University and on the death of his father, in 1721, he was chosen to succeed him in the professorial chair, a post which he held for nearly fifty years. He was an incomparable lecturer but his claim to everlasting fame is that he published a number of anatomical atlases, some of which have never been surpassed in the beauty and accuracy of their illustration and the elegant style of the accompanying text. The most outstanding deals with the bones and muscles, it was published in 1747 with the title *Tabulae Skeleti et Musculorum Corporis Humani*. The drawings and engravings were made by Jan Wandelaar. In order to gain exact proportions, many anatomical drawings were made from actual bodies, they were measured carefully and were then averaged in order to gain the final result. For the drawing of skeletons ingenious contrivances were suggested by a professor of physics. Two nets, as large as the skeleton itself, were divided into squares. They were placed in front of the skeleton, one very close and the other, with squares ten times as small, about four Rhenish feet away. The artist stood forty feet distant from the object, and by means of the two nets gained proper perspective. In order to depict more accurately such parts as could not be distinguished from a distance he could approach the first net closely and, by relating his drawing to the larger squares, could still record detail accurately in proportion to the whole. An account of the method may be read in the preface to the book. Curious and interesting are the accessories to the figures which were chosen, by which to give an impression of proportion (Figs 8 and 9). They are thus in contrast to the figures in other anatomical works where accessories are quite unrelated to the subject in hand.

These anatomical atlases were vital necessities to students of anatomy and surgery whose chances of learning anatomy by dissection were few. Hoffman at Halle secured no more than twenty bodies for dissection in twenty-four years. In Prague there were only three dissections in the twenty years after 1692, and Albinus himself obtained only one body each year. Yet, after two hundred years the Albinus *Atlas* remains unsurpassed. Even to-day its pictures convey something of the enthusiasm of pioneer anatomist-surgeons who never lost sight of their interest in the anatomy of the living. Their successors, whose work has been so much concentrated on the formalin-hardened dead, have in this respect much to learn.

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IN MEMORIAM

**PROFESSOR JACQUES LEVEUF**  
1886-1948

By the death of Professor Jacques Leveuf at the height of his powers, French orthopaedic surgery has been deprived of an outstanding modern leader. Leveuf had many close ties with Great Britain. His dynamic personality had become one of the features of recent meetings of the British Orthopaedic Association of which he was elected an Honorary Member in 1945. After the liberation of France he was eager to establish contact with his British colleagues and to expound with characteristic vehemence and eloquence his views on congenital dislocation of the hip, on acute osteomyelitis, and on many other subjects in which he appeared always to challenge orthodox beliefs and practice. Leveuf was born in Limoges and studied in the School of Medicine in Paris. After the usual junior interne appointments he was for many years an assistant in the surgical clinic of Pierre Delbet. He worked with Delbet in the early attempts to nail fractures of the femoral neck under X-ray control. This experience no doubt largely determined his choice of the surgery of bones and joints as his life work. In due course he achieved the coveted status of "Surgeon to the Hospitals of Paris" and became surgeon-in-chief at the Bretonneau Hospital. In 1942, on the retirement of Professor Ombredanne, Leveuf was chosen as his successor at the Enfants Malades and in the Chair of "Infantile and Orthopaedic Surgery"—the blue ribbon of Paris orthopaedics. In the new surgical clinic designed by Ombredanne, Leveuf began to work with ever increasing intensity on the problem of the treatment of congenital dislocation of the hip by open reduction. Before the war he had carried out a survey of the late results of manipulative reduction in the province of Brittany, where the deformity was exceedingly common, and had been impressed by the high proportion of poor results. During the last two years he had established a centre in Brittany for the diagnosis and treatment of this deformity. Arthrography, a technique in which he was a master, was practised on the newly born, and

many interesting observations had already come to light His aim was to recognise those dislocations in which an interposition of soft tissues existed which would prevent the concentric re-position of the femoral head into the depths of the socket Once this anomaly had been demonstrated it was, in Leveuf's view, a waste of time attempting to treat a congenital dislocation by manipulation

Leveuf attended the Annual Meeting of the British Orthopaedic Association in Manchester in October 1947, and appeared to be full of vigour In the early part of 1948 he attended the meeting of the American Academy of Orthopaedic Surgery in Chicago After his return from the United States it became evident that he was a tired man, and very soon there were unmistakable signs of the grave malady which brought his life to an end Jacques Leveuf's death will be deplored throughout the world, not merely because of the many friendships which had made him an international figure, but because he had great contributions still to make to the art and science of orthopaedic surgery

H P

Professor Jacques Leveuf has been taken away suddenly at the age of sixty-three in the midst of a strenuous surgical and scientific life Many cultural, literary and artistic interests showed the breadth of his intellect Above all his character was notable for a swiftness of comprehension His passion for surgery, and the flame of his enthusiasm, led him to express views with an ardour which won furious opposition, or enthusiastic support, but never indifference With this impetuosity he nevertheless had the rare quality of being able to change his mind and modify his views quickly This agility of mind, enthusiasm, and direct approach kept him surprisingly young

He made of the Clinique des Enfants-Malades a complete service, directing a group of distinguished colleagues, and himself taking a leading part in the orthopaedic surgery of children in which he was so interested, in traumatology, neurosurgery, and plastic surgery A member of the Academie de Chirurgie, the British Orthopaedic Association, and the American Academy of Orthopaedic Surgeons, he made his contribution with a fervour which commanded wide attention and interest not only in France but in the world A great void is left in the surgery of France

R M D'A

#### MISS EUGENIE LEESON WILLIS 1910-1948

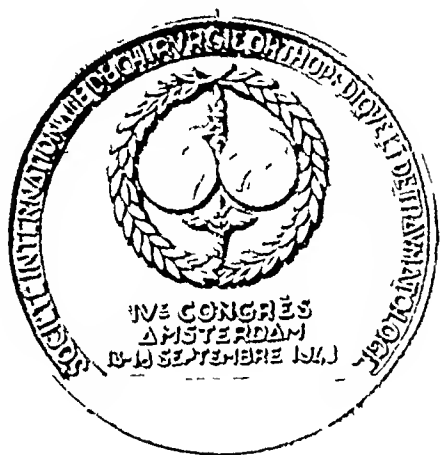
A career of promise has been cut short by the death of Miss Willis after a long and disabling illness which she faced with characteristic courage A graduate of Cambridge and of the London School of Medicine, Miss Willis was one of the few women members of the British Orthopaedic Association and one of the few women to obtain the Fellowship of the Royal College of Surgeons of England After a period of junior resident appointments in her own teaching hospital she was appointed Resident Surgical Officer at the Oldham Royal Infirmary in 1940 In 1942 she was appointed to the Manchester Royal Infirmary as Chief Assistant in the Orthopaedic Department, a post in which she had to bear added responsibility in the treatment of many battle casualties coming to that hospital at a time when its surgical staff was greatly depleted by the calls of the Services She also served the University of Manchester in the Departments of Orthopaedic Surgery and Anatomy The long hours of labour and the rich experience which fell to her lot during those years should have been the prelude to a long and distinguished career as an orthopaedic surgeon, but before the end of the war the symptoms of the disease from which she died had already appeared Despite a suspicion that her active life would be short, and despite the certainty which soon replaced that suspicion, Miss Willis continued her work in a manner which excited the admiration and respect of all her colleagues She retained courage and good spirits to the end, and is sincerely mourned by patients and colleagues alike

D LI G

# PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

# INTERNATIONAL SOCIETY OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY

The fourth congress of the International Society of Orthopaedic and Traumatic Surgery was held in the famous Indisch Instituut Amsterdam during the week September 13 to 18 1948 under the patronage of Her Majesty Queen Wilhelmina. Two hundred delegates attended from twenty-seven countries. The congress owed much to the Dutch capacity for smooth organisation which was personified in the secretary Dr J. D. Mulder. On several occasions the president of the congress Dr Henry Meyerding expressed his relief that more trouble had not arisen in the timing of sessions which on paper were filled and indeed hopelessly overfilled with vast numbers of contributions. One of three days of scientific proceedings was devoted to reports on closed fractures of the spine another to arthritis deformans of the hip joint, and a third to a series of short papers.



Medal struck on the occasion of the Fourth Congress of the International Society of Orthopaedic Surgery and Traumatology held in Amsterdam

The Institute had a large and a small lecture hall and two licensed restaurants. Coffee was served continuously in the entrance hall where there was also an exhibition of instruments and books. These diversions were in great demand for many contributions were delivered in languages with which few were familiar. In the scientific exhibit attention was attracted by many excellent instruments for osteosynthesis which included bone clamps based on the designs of Professor Lambotte who now lives quietly in a suburb of Antwerp and pursues his hobby of making violins and cellos with superb craftsmanship. The circular saw designed in Great Britain by Messrs Desoutter Bros. had been modified by a Belgian firm in such a way as to act in a longitudinal axis and the intermittent whine of this instrument was the basic musical note of the congress. It served as a desecant to every conversation. Apart from daily scientific sessions at the Institute two very enjoyable evening receptions were held in the Rijksmuseum and the Stedelijk Museum. The galleries were thrown open to members and guests. The Rijksmuseum included not only its own treasures but also the touring Munich collection and the Stedelijk Museum once again housed its famous collection of Van Goghs so that the receptions were of particular interest.

At the general meeting there was comment and discussion on difficulties which had arisen from the language problem it was urged by some that contributions should be delivered in French or English and that lantern slides should include legends in several languages There was also debate on the constitution of the Society and the method by which members and delegates were elected It was decided that the next Congress should be held in Stockholm in 1951 and that Professor Richard Seherb of Zurich should be president The main subjects selected for discussion were ' Bone Changes in Avitaminosis and Low Back Pain Sir Harry Platt (Great Britain) was elected president of the Society and Professor C Sorrel (France) and Dr San Ricart (Spain) vice-presidents

**Closed Fractures of the Spine**—The discussion was opened by *E A Nicoll* (Great Britain) whose findings were based on a long-term review of dorso lumbar fractures in miners. He classified these injuries with special reference to lateral wedge fractures and isolated fractures of the neural arch. Lateral wedge fractures had anatomical and clinical characteristics which differentiated them from anterior wedge fractures. Isolated fractures of the neural arch were sub-divided into those above the fourth lumbar

vertebra which had little or no tendency to forward displacement, and those at the fourth-fifth lumbar levels which if untreated caused progressive spondylolisthesis. Early recognition was essential, and if displacement had already occurred open reduction and grafting was advocated.

In a study of the relationship between long-term anatomical and functional results no support was found for the assumption, on which orthodox treatment had been based for many years that perfect anatomical position was indispensable to perfect function and was the essential objective in treatment. This was illustrated by individual case records and statistical analysis. Redisplacement after closed reduction and prolonged immobilisation was common, it was due to comminution of the vertebral body, crushing of the intervertebral disc, or rupture of the interspinous ligament, all of which could and should be recognised at the outset.

The important factor in determining function was stability between the injured segments, and not the position in which stability was achieved. For the purposes of treatment, cases were divided into stable and unstable types. Stable types included anterior and lateral wedge fractures and fractures of the neural arch above the fourth lumbar level. Unstable types included fracture-dislocations and fractures of the neural arch at or below the fourth lumbar level. Stable fractures were treated after a short period of rest in bed as soft tissue injuries. Unstable fractures were treated by protective plaster in a position permitting anterior stabilisation or by open reduction and grafting. When there was paraplegia immediate open reduction and grafting was recommended in order to restore the lumen of the neural canal and produce a stable spine at the earliest possible moment thus permitting early ambulation and avoiding urinary complications. In such operations it was essential to avoid plaster fixation which almost invariably caused pressure sores. The graft must be self stabilising, and one such type of graft was demonstrated. It was urged that more regard should be given to soft tissues, it had been proved that prolonged immobilisation of damaged soft tissues in a shortened position caused disabling symptoms. *Lorenz Bohler* (Austria) said that the three essential principles of treatment were complete reduction, absolute immobilisation and exercises during and after the period of fixation. It was possible to secure complete reduction only during the first two weeks. The ideal time for reduction was the day after injury when two thirds of spinal fractures could be reduced by the closed methods of Davis or Watson-Jones, the other third could be reduced in the supine position. Exercises in plaster were illustrated by a film. Even after four months immobilisation, patients could bend forward and touch their toes immediately the plaster was removed. If correction of deformity could not be achieved, fixation in plaster was not indicated. Exercises were then started after two weeks. Fractures of the upper dorsal spine could be reduced only during the first week and only in patients under thirty years of age. A plaster cast was applied to the trunk which was hyperextended in the supine position. The patient was then sat up and a Glisson sling used while the neck and head were incorporated in plaster. The cervical spine was not hyperextended and the chin was left free. Fractures of spinous and transverse processes were treated as soft tissue injuries by immediate active exercises. Fractures and dislocations of the cervical spine were reduced by skull traction, and a plaster cast was applied without hyperextending the neck. When there was clinical evidence of complete paraplegia, death was usual within forty-eight hours. Reduction of fractures complicated by damage to the spinal cord was useless at any level if there was complete motor and sensory loss—no attempt at reduction should be made, but if clinical signs pointed to an incomplete lesion of the cord reduction of the fracture and immobilisation in plaster for five or six months was indicated. This was combined with skeletal traction to both legs through the tibial tuberosities.

**Operative Treatment of Closed Injuries of the Spine**—*Carlo Pans* (Italy) reported six hundred cases treated at the Rizzoli Institute. Operative treatment was never undertaken until the third or fourth week after injury. There were three main indications: to secure reduction where conservative efforts had failed to maintain reduction in unstable cases and to decompress a damaged cord. The usual cause of failure of closed reduction was locking of articular facets, but grafting was seldom used in these cases after open reduction. Spinal fusion was indicated as a delayed operation when there was persistent pain due to deformity, non-union, secondary arthritis or spondylolisthesis. When there was involvement of the cord with evidence of bone pressure, decompression laminectomy was performed after three weeks. Queckenstedt's test was essential and myelography was often used. It was unnecessary to open the dura. A film illustrating the technique of decompression laminectomy gave a beautiful demonstration of the fact that disc material or bone fragments were often pressed back on the anterior aspect of the cord during attempted closed reduction. The posterior arches were excised, the dura retracted and projecting pieces of bone or disc material removed from the anterior aspect of the cord. Decompression laminectomy was also carried out at later stages if spinal block could be demonstrated and the patient was not making good progress. In late laminectomies it was essential to open the dura because arachnoid adhesions were common and should be freed. The results in late cases were however, disappointing. Operative treatment was also indicated in painful and spastic conditions resulting from paraplegia. When spasticity was predominant postero-lateral cordotomy was indicated but when pain was the chief symptom antero-lateral cordotomy should be performed.

**Paraplegia due to Vertebral Fractures**—*Henry Heyerdal* (United States of America) dealt with the rehabilitation of patients with vertebral column fractures complicated by spinal cord injury. When the cord was transected surgical and nursing problems were serious and complex. The economic and social problems of cases which were not rehabilitated taxed the resources of both family and community. Care should be taken in early stages to avoid pressure sores by frequent change of position to prevent contractures by daily passive movement and to arrest urinary infection by chemotherapy and early mobilisation. Resisted exercises for the development of muscles used in crutch walking were started in bed at the earliest possible moment. Abdominal and spinal muscles concerned in maintenance of the upright posture were also developed. Exercises were then carried out on a mat and between parallel bars in which the patient acquired a sense of balance and learned to support weight on his arms. In the final stages various crutch gait were taught: they were based on the classical work of Deaver of New York. Patients must be able to get up and down stairs and to cross a wide road between changes of traffic lights. Another method of progression which relied on the sitting position with sawn off tripod crutches was of particular interest to this writer a few days later when he saw an exactly similar method depicted in a sixteenth century printing in the Rijksmuseum. All patients were provided with folding wheelchairs. Vocational instruction was given so that they might become economically independent. Training and resettlement called for the co-operation of many services. It was essential that the team of specialists in orthopaedics, physical medicine, urology and psychiatry should be endowed with optimism and with enthusiasm which communicated itself to the patient and prevented him from becoming a dependent invalid. These facilities could be provided only in highly specialised institutions and segregation in special centres was urged. The expense of making these patients independent was less than the cost of maintaining them as permanent invalids.

*A. Bonola* (Italy) demonstrated the suspension apparatus used for re-education of paraplegics at the Rizzoli Institute, Bologna. The patient was suspended by a harness fixed to a track in the ceiling. Bivalved plaster leg splints were worn and in the later stages braces with locked knees. The patients used a walking machine in which leg movements were activated by hand controls.

*P. Magnuson* (United States of America) said that in the United States Department of Veterans Affairs the treatment of traumatic paraplegia had been segregated in eight centres. Two thousand cases were constantly under treatment and now that civilian cases were being admitted the number was increasing. It was essentially a team job. In primary treatment the orthopaedic surgeon and neurosurgeon played an important part. Early laminectomy with fusion gave the best results: there were less trophic complications and there was less pain. Early walking exercises in suspension apparatus restored a sense of balance and helped to avoid urinary complications. Psychological problems were important. One of the best stimulants in the United States of America was a lovely girl paraplegic at the eighth dorsal level who herself had achieved a remarkable degree of rehabilitation and toured their centres regularly. It was perhaps unfortunate that in the United States pensions for paraplegia due to Service injuries guaranteed financial security to such an extent as to reduce the incentive of the patient.

*P. Lewin* (United States of America) stressed the value of Stryker frames in avoiding pressure sores. The oscillating bed improved nitrogen balance and prevented stone formation. Fascial transplants in patients with paralysis of the abdominal wall were valuable.

**Sequelae of Vertebral Fractures**—*San Ricart* (Spain) discussed the sequelae: pain, deformity, stiffness and paralysis. Treatment was discussed under three headings: mobilisation, fixation and neurosurgical operations. Treatment by mobilisation included various forms of heat to soften scar tissue and aid resolution of fibrosis: it was useful in fractures of transverse and spinous processes and in the treatment of secondary curvatures due to muscle contracture. Treatment by fixation included temporary support by plaster casts and leather corsets and permanent fusion by spinal operation which was indicated in Kummel's disease and traumatic spondylolisthesis where mobility was limited and painful. When spinal fusion was under consideration temporary fixation in plaster should first be used as a therapeutic test. Flexible types of osteoperiosteal graft were preferred: the patients were nursed on a firm mattress without plaster fixation for a period of four to six months. Neurosurgical procedures included novocain injection and surgical interruption of the pathways of pain. When there was disc prolapse two or three complete arches should be resected in order to gain adequate exposure. If lipiodol had been used the dura should be opened so that the oil could be extracted completely.

**Second thoughts on the Discussion on Spinal Fractures**—*Alberto Inclan* (Cuba) and many other speakers contributed to this discussion. In retrospect the lasting impression which remains is that of wide differences of opinion which still exist even on fundamental principles of treatment. For example—the objective must be anatomical perfection: the objective must be stability which is often incompatible with anatomical perfection: again—in the management of paraplegia open reduction must be immediate: operation must never be undertaken in the first four weeks: once more—the fracture should be ignored, the fracture should be immobilised in hyperextension: the fracture should be immobilised in the neutral



position and so on. An intelligent visitor who had never read a text-book of orthopaedic surgery might reasonably be excused for confusion and for wonder that nine-tenths of a surgical discussion should be devoted to the technique of achieving half a dozen different objectives, and only one-tenth to discovering the right objective to pursue.

**Treatment of Osteoarthritis of the Hip Joint**—*P. Mathieu and P. Padovan* (France) reviewed developments of arthroplasty by the interposition of fascia, acrylic resins and vitallium cups. Such technique preserved length of the femoral neck and usually made it unnecessary to displace the greater trochanter downwards. Massive prostheses of the femoral head made from fine acrylic substances and fixed to the stump of the femoral neck by an axial shaft had been used recently in France. The bifurcation operation of Lorenz, and other types of osteotomy, had not justified earlier hopes. The results of drilling the femoral neck and of joint neurectomy were very inconstant. Arthrodesis of the hip with a three-flanged nail or bone graft was the best palliative operation.

*J. Zahradníček* (Czechoslovakia) discussed various forms of conservative treatment. He said that it was unwise to induce hyperaemia of the joint: treatment by radiant heat and diathermy was a failure; on the contrary, blood supply should be reduced by rest and cold compresses. The merits of deep X-ray therapy had been overestimated. Tissue therapy with transplantation of a piece of fresh refrigerated placenta under the skin of the abdomen had led to improved function of the joint, relief of pain and 'refreshing' of the whole organism.

*E. La Chapelle* (Netherlands) said that in preference to arthrodesis of the joint he performed shelf operations: arthroplasty with vitallium cup, joint resection and reconstruction, osteotomy, or decapsulation. The results of denervation operations were uncertain. For the drilling operation "there could hardly be found an indication."

*J. Delchef* (Belgium) said that although arthrodesis of the hip joint was no more than palliative, it relieved pain with certainty and gave the patient almost perfect function. His practice was to embed a bone graft in an intra-articular trough without completely denuding the joint surfaces, thus shortening the time of operation and reducing shock. The limb was immobilised in a full plaster spica for three months and a short spica for another three months. The disadvantage was the tendency to stiffness of the knee joint.

*G. H. Iberg* (Sweden) advocated arthrodesis of the hip joint with nail fixation as originally recommended by Watson-Jones, the operation being done in one or in two stages. Fixation by means of a nail alone should not be used unless the joint was already almost ankylosed by the disease. A serious disadvantage of fixation by nail alone was that deformity could not be corrected fully. The use of a tri-flanged nail in supplementing routine arthrodesis of the joint, which included complete denudation of articular surfaces, was a most valuable contribution.

*M. A. Smith Petersen* (United States of America) reviewed the history of development of arthroplasty of the hip joint. He described his approach and the technique of reconstructing joint surfaces. The importance of post-operative care was illustrated by lantern slides and a film. It was emphasized that although mould arthroplasty had been performed on a fairly extensive scale for many years, the results after ten years were not to be regarded as 'end-results'.

**Fractures in Paget's Disease**—*O. Stracker* (Austria) said that union occurred rapidly in the fractures of Paget's disease. He treated severe bowing of the femur or tibia by cuneiform osteotomy and plating. **Ewing's Sarcoma**—*J. Valls* (Argentina) discussed the differential diagnosis between Ewing's sarcoma and osteosarcoma of Huesco: they were liable to be confused on radiographic examination but there were marked histological differences. The prognosis was different. One patient with a reticulo sarcoma of Huesco survived, and well eight years after being treated by deep X-ray therapy.

**Cancellous Chip Grafting after Internal Fixation of Fractures**—*J. Thomson* (United States of America) urged that non-union of fractures should be supplemented by grafting cancellous bone chips from the ilium. Statistics from two groups of cases, one treated by internal fixation alone and the other by internal fixation with cancellous chips, showed marked increase in the rate of union in the latter group of fifty-two cases. The cases which had been open fractures. In established non-union, an intra-medullary nail supplemented by cancellous chips had given good results.

**Paralytic Scoliosis in Children**—*A. Gruca* (Poland) said that extra-articular grafts failed to increase in length during growth of the patient so that they could be used to secure gradual correction of the deformity. He used a rib graft on the convex side of the primary curve. The fourth or fifth rib was dissected free, and after division of the rib beyond the transverse process it was swung down and fused at its lower end to a lumbar transverse process. At the same time a tibial strut was placed between a lumbar transverse process and the crest of the ilium on the concave side of the secondary curve, but in order that this graft might increase in length epiphyseal cartilage was included in it.

**Tendon Transplantation for Radial Nerve Paralysis**—*Meile D. Aubigne* (France) showed a film. The palmaris longus was transplanted into the extensor pollicis longus and brevis, the flexor carpi ulnaris into the extensor communis, and the pronator radii teres into the radial extensors of the wrist. A good end result was demonstrated.

**Volkman's Ischaemic Contracture**—*O. Seasholtz* (Italy) described a radical operation illustrated by an excellent film the whole flexor group of muscles being dissected with nerve and blood supply intact from the lower end of the humerus and from the origins in the forearm. The operation had been performed four times in children. The results appeared to be an improvement on those of the more conservative types of muscle slide which are usually practised but the operation had been done at so early a stage that some were in doubt as to whether simple conservative treatment might not have succeeded.

**Ununited Fractures of the Scaphoid**—*Paul B. Shack* (United States of America) said that formal arthrodesis of the wrist joint was a difficult operation requiring skill and experience and that it was unnecessary in uncomplicated non-union of fractures of the scaphoid. The operation he advocated was simple: a disc of osteoperiosteal bone including the ununited fracture and part of the semilunar and capitate bones was trephined from the back of the carpus and rotated through 180 degrees thereby securing localised fusion of the carpus without interfering with mobility of the wrist joint or the carpometacarpal joints.

**Traumatic Dislocation of the Hip Joint**—*Loren Bohler* (Austria) discussed the treatment of traumatic dislocation of the hip joint in relation to vascular necrosis. A series of forty-eight cases was reported none with fracture of the rim of the acetabulum which had been treated by early mobilisation and weight-bearing. After reduction, and support in a splint for seven days the patient began free exercises in bed. In three weeks he was allowed weight bearing; in three months he was back at full work. It was claimed with pride that there had been only one case of aseptic necrosis. Some think that the inference is not at all obvious, they would prefer to wait the results of follow-up.

**Congenital Aplasia of the Femur**—*C. Van Nes* (Netherlands) said that in most cases the ankle joint was at approximately the same level as the normal knee joint and if it could be turned round through 180 degrees it could be used as a knee joint in a prosthesis. A case was demonstrated in which there was also pseudarthrosis of the upper femoral shaft. This was fused and at the same time rotation osteotomy was performed. At a second operation the knee joint was fused and in due course a modified below-knee prosthesis was fitted. The patient demonstrated remarkably good function and satisfactory control of the knee mechanism of the prosthesis. Four cases had been dealt with and all were satisfactory.

**Opaque Arthrography of the Knee Joint**—*N. L. Capener* (Great Britain) said that arthrography was useful not only in the study of congenital dislocation of the hip joint but also in pathological disturbances of other joints. Radiographs were shown in which 35 per cent diodone had been used—an innocuous material which was absorbed rapidly. Forty-six knee joints had been investigated without ill effect; indeed some patients with osteoarthritis claimed to have gained benefit. Torn cartilages could be demonstrated but clinical tests were more important.

**Recurrent Dislocation of the Patella**—*B. Boitcher* (Bulgaria) demonstrated an operation in which the medial half of the ligamentum patellae was transposed to a more medial attachment on the tibia and the vastus lateralis was then freed from the patella and a musculo-aponeurotic flap from the medial part of vastus medialis was brought under and through the lateral muscle near its attachment to the patella and sutured to bone. Thus when the quadriceps contracted the transposed muscle exerted a medial pull on the patella.

**Tarsal Fusion for Tuberculosis**—*J. Samson* (Canada) described arthrodesis for tuberculous disease of the tarsus by an inlay graft cut from the ilium and countersunk into the required area.

**Equalisation of Leg Length**—*J. Verbrugge* (Belgium) advocated shortening the normal leg at the subtrochanteric level instead of in the middle of the femoral shaft where approach was more difficult and union less certain and less rapid. Apposition and alignment could be maintained easily by means of a long screw.

**New Power-driven Saw for Femoral Osteotomy**—*A. Campiglio* (Italy) recalled Professor Putti's dictum that the correct instrument for cutting bone was a saw and not a chisel. A saw had been devised which revolved in the same plane as the cylindrical handle on which it was mounted. The position of a drill hole in the bone at the level and in the direction required was confirmed by radiographic examination. Special bone levers with wide flanges protected the soft tissues. The blunt guide on which the saw blade was mounted was then introduced along the drill-hole and the bone was divided.

**Kuntscher Nail in the Treatment of Fractures of the Femur**—*L. Bohler* (Austria) said that the Kuntscher nail should be used only for fractures of the upper femoral shaft. An assistant maintained radiographic control of the position of fragments by means of a long periscope with a mirror at an angle of 45 degrees thus avoiding the effects of direct radiation.

**The Anna Clinic, Leyden**—The last two days of the conference were devoted to clinical meetings. This writer visited the Anna Clinic which is famous for the work of Murk-Jansen and is now under the direction of Dr Van Nes. A large portrait of Sir Robert Jones stands in the entrance hall and his signature occupies a place of honour in the visiting book. Dr Van Nes gave a remarkable demonstration of major surgery on two successive mornings. In the course of four and a half hours operating he performed two cup arthroplasties of the hip, two arthrodeses of the hip, one shortening of the femur with plating and grafting, one spinal fusion with graft and two capsulectomies of the hip joint. The pace of work was quite

remarkable. It was made possible by abandoning the changing of gloves and gown between operations and by using a trained staff to apply all plasters. Throughout the time that he was at work, Dr Van Nes explained his technique in four languages. One feature of his surgery of the hip joint was the medial approach. He seldom reflects the gluteal muscles. On the other hand he lifts the iliacus off the inner wall of the pelvis and holds it retracted by a Steinmann pin hammered into the bone thus giving wide and free exposure of the hip joint and making it possible, for example, to insert sharp stainless steel nails from the pelvic aspect of the acetabulum in arthrodesis of the joint. In arthroplasty of the hip the refashioning of acetabulum and femoral head was carried out with great rapidity and with little of the finesse which is claimed to be essential by Smith-Petersen. On the last day we enjoyed a most impressive demonstration of after-results in a large number of patients who were displayed with speed and facility. The Anna Clinic works under remarkable pressure. Operation lists, comparable to the ones we saw, are completed on six days every week. The turn-over of major cases in no more than 130 beds is remarkable. Many are transferred to the convalescent home on the afternoon of operation.

## AUSTRALIA

### ANNUAL MEETING OF THE AUSTRALIAN ORTHOPAEDIC ASSOCIATION, 1948

The eighth annual meeting of the Australian Orthopaedic Association was held in Perth (Western Australia) from August 11 to 13, 1948, under the presidency of Mr John Hoets (Sydney). The attendance was good, although for many it involved a "round trip" of 6000 miles.

**Primary Malignant Tumours of Bone**—This paper by *Sir Harry Platt* (Manchester, England) was read in his absence. He classified 187 documented cases into bone sarcoma, haemopoietic tumours in bone, and adamantinoma. Two groups might be distinguished: extraosseous tumours in which the main mass could be felt superficial to the affected bone, and intraosseous tumours which included myxo-chondroma, giant-cell tumour and haemopoietic tumours. In reviewing five-year cures he affirmed that biopsy before amputation was both useful and safe. Pre-operative radiation was condemned as a waste of time. His series of 114 accessible tumours treated by radical operation, included twenty-six five-year cures—nineteen of osteogenic sarcoma and seven of extra-periosteal sarcoma. He had done six hind-quarter amputations with only one death. He believed that the merit of surgical eradication of tumours was proved. Amputation remained the chief contribution of surgeons to lasting cure, but local resection might be possible in a few selected cases. *Dr J. Hoets* (Sydney) had also seen bad results from pre-operative radiation in osteogenic sarcoma and advised early amputation. *Mr E. F. West* (Adelaide) advocated biopsy in all cases.

**Chondromalacia Patellae**—*Mr V. S. Gunning* (Adelaide) reviewed the results of twenty-five cases of chondromalacia of the patella treated by operation. The cause remained obscure and might be the result of direct trauma or of chronic infection of the knee joint. The most frequent symptoms and signs were swelling, subpatellar tenderness, inability to climb stairs, pain on moving the knee with pressure over the patella and crepitus. When there was no generalised arthritis complete excision of the patella gave good results, but there was often post-operative tenderness over the lateral margin of the femoral condyle. He considered that chondromalacia patellae was a frequent cause of the advanced arthritis seen in later life. *Mr E. F. West* (Adelaide) ascribed the degenerative changes to continuous friction under tension. He had noted them in recurrent dislocation of the patella for which he advocated excision of the patella.

**Late Results of Surgical Treatment of Tuberculosis of the Hip**—*Miss Elizabeth McComas* (Melbourne) reviewed cases of tuberculosis of the hip joint treated at the Children's Hospital, Frankston, since 1930. Fifty-six patients were treated conservatively, with eight deaths, and thirty-two by operation, with four deaths. Arthrodesis was performed in twenty-three cases, sound ankylosis was achieved in sixteen. The failures were all operated on at a young age, the youngest being six years. The average duration of conservative treatment before operation was five years. *Mr J. Lahrz* (Brisbane) had used both the Wilson and the Brittain type of arthrodesis, and he thought that weight-bearing with external fixation promoted growth of the graft. *Mr J. Jens* (Melbourne) considered that shortening was aggravated by fixation in plaster, and preferred to use traction. *Mr McKellar Hall* (Perth) stressed the mild nature of the disease in Western Australia where sinuses did not develop and the need for arthrodesis seldom arose.

**Rôle of the Subscapularis Muscle in Stability of the Shoulder Joint—Magnuson Operation**—*Mr John Jens* (Melbourne) said that much could be learnt as to the stabilising effect of shoulder girdle muscles by considering the disabilities of poliomyelitis in which the medial and lateral rotator muscles of the shoulder had been paralysed. The head of the humerus could be moved passively in and out of the glenoid cavity. He demonstrated anatomical variations in the joint which predisposed to dislocation. High insertion of the subscapularis tendon, with absence of fibres reinforcing the anterior capsule and extending down the shaft, weakened the musculo-tendinous cuff and had been found in two cases of recurrent dislocation recently operated upon. He described in detail reinsertion of the subscapularis tendon by the Magnuson technique which had the object of limiting lateral rotation by approximately 50 per cent.

To secure a buttress action across the front of the joint it was often necessary to lower the tendon insertion by half to three quarters of an inch. It was important that spread of the muscle should be maintained and in fixing the tendon to its new attachment he advocated the use of two or three staples. It was considered unnecessary to remove a bone block of the lesser tubercle as advocated by Magnuson and Stack. He believed with other writers that the important factor in preventing redislocation was the establishment of a sound elastic buttress in front of the joint together with limitation in the range of lateral rotation. Though his series of cases was limited he believed that the operation was no less effective than the more complicated Putti-Platt procedure.

Papers were also read on *De Quervain's Disease* by Mr B. T. Keon Cohen and *Supracondylar Fractures of the Ulna* by Mr A. V. McEwan. Two clinical sessions were held. It was decided that the National Health and Medical Research Council should be asked to finance or initiate research into the epidemiology of poliomyelitis. The officers elected included D. J. Chesson (Sydney) president, D. W. L. Parker (Hobart), B. T. Keon Cohen (Melbourne) and N. S. Cunningham (Perth, S. Australia) vice-presidents, A. R. Hamilton (Sydney), honorary secretary, G. K. Smith (Melbourne) honorary treasurer, W. L. Macdonald (Sydney), honorary editorial secretary and A. C. A. Hunter, H. C. Barry, R. J. B. McEwen, L. J. Woodhead members of committee.

### AUSTRALIAN MEDICAL CONGRESS OF THE BRITISH MEDICAL ASSOCIATION SECTION OF ORTHOPAEDICS AND PHYSICAL MEDICINE

The Australian Medical Congress of the British Medical Association 1948, took place in Perth (Western Australia). The orthopaedic and physical medicine sections met from August 17 to August 20 under the presidency of Mr C. W. B. Littlejohn, C.B.E.

**Conservative Treatment of the Injured Back**—*Mr S. W. Scougall* (Sydney) recalled that muscles and ligaments as well as intervertebral discs could be injured. Treatment was limited by ignorance of the physiology of posture. He discussed cortical analysis of pain and the structures concerned in the 'rest mechanism' as applied to the back. Defence against muscular fatigue were ligamentous locking, bilateral alternation, and the fascicular chain contraction of tonus. A fixed spinal list in low back lesions not only prevented this alternating rest mechanism and promoted fatigue and pain but also overloaded muscles on the convex side so that patients with loss of postural equilibrium due to a list should not be allowed about. The part played by muscle spasm in sciatic scoliosis and the rationale of recumbency, traction and plaster fixation was considered. Effleurage sedation or possibly local anaesthesia aided the application of a jacket in normal posture. Fixation should be maintained for not less than six weeks if a disc lesion was suspected. The mechanics of lumbar movement were discussed and the importance of disc senescence in the production of prolapse was emphasized. Manipulation of the spine had no more than a minor role in treatment and if disc protusion was suspected only the relatively safe manoeuvre of rotation towards the affected side should be performed.

**Indications for Operation on the Injured Back**—*Mr E. F. West* (Adelaide) discriminated between conditions requiring immediate operation such as locking of articular processes which might require facetectomy or the rare instance of cord compression from acute retropulsion of an intervertebral disc or bone fragment and conditions which might require late operation when symptoms arose some time after the injury. Compression fracture incompletely reduced was likely to produce localised spondylarthritis from malalignment of the posterior intervertebral articulations. In older patients conservative treatment with an efficient support should be tried first but in younger individuals arthrodesis was preferred. Disc lesions in the lumbar spine demanded conservative treatment at first recurrence called for exploration. In later life arthrogenic sciatica was common. Radiographs revealed pronounced thinning of the disc space and apophyseal arthritis. For this condition arthrodesis was advised. The sciatica of spondylosis was usually arthrogenic and could be relieved by arthrodesis. Conservatism should be the rule in the treatment of low back disability and in considering the indications for operation, due regard should be paid to the psychological background of the patient.

**Treatment of the Injured Back by Physical Medicine**—*Dr Frank May* (Melbourne) said that the commonest cause of low back disability was muscular or ligamentous strain. He discussed acute strain of muscles and fasciae and methods of relief of pain by which to promote early active movement. Novocain injection was important in diagnosis as well as treatment. Early treatment prevented chronic traumatic fibrositis. Conditions predisposing to back-strain namely faulty posture, obesity, spondylosis, kyphosis and congenital anomalies were reviewed. Methods of physical therapy were demonstrated.

**Routine Treatment of Compound Fractures**—*Mr John R. S. Lahz* (Brisbane) recalled that in 1865 Joseph Lister successfully treated a compound fracture of the tibia by the carbolic antiseptic technique. First-aid management and pre-operative preparation were discussed. Tourniquets which caused tissue anoxia were to be avoided. Liberal irrigation of the wound with a mild antiseptic solution such as 50 per cent Dettol or 1/1000 Monacain under pressure was advocated. Meticulous wound toilet was

imperative without manipulation of the bone ends if this meant more than simple leverage of fragments which were seen and handled easily. Plating open fractures was ill-advised because it increased the risk of infection and reduced blood supply to the damaged bone. Fascia should not be sutured under tension. The skin should not be sutured if operation was performed more than eight hours after injury or if there was a gaping wound. Tight bandaging might cause slight and often unrecognised ischaemia.

**Primary Internal Fixation of Fractures**—*Mr B Keon-Cohen* surveyed one hundred and eighty seven closed fractures and forty-seven compound fractures treated by primary internal metallic fixation. The indications for internal fixation were 1) to maintain reduction of unstable fractures, 2) to secure efficient immobilisation after complete reduction in those fractures which were slow to unite and 3) to simplify the management of multiple fractures. Interposed soft tissue was an important cause of difficulty in reduction and delayed union, notably in spiral fractures of tibia, fractures of the medial malleolus, and many fractures of the humerus and femur. Intramedullary nails were valuable in fractures in the upper half of the femoral shaft. At operation a tourniquet was used whenever possible. Adequate exposure was secured by incisions so placed that plates and screws were neither subcutaneous nor crossed by the suture line. All operations were performed under penicillin control. Complete immobilisation of the wound was the most important single factor in promoting sound healing. All patients with tibial fractures except those with bone loss were allowed to walk in a caliper splint after three weeks. With a Kuntscher nail in the upper third of the femur the patient took weight without support in three weeks and with other femoral fractures after six to eight weeks. Movement of the shoulder, elbow, and forearm joints was begun after ten days with fractures of the humerus, and in four to six weeks with fractures of the forearm bones. Five instances of sepsis had occurred, all of which cleared up after removal of the metal. In the past eighteen months forty-seven compound fractures had been treated by primary internal fixation. Thirty-four healed by first intention and eight after minor degrees of superficial skin sloughing which did not affect progress. It seemed safer not to wait for the wound to heal, and for delayed union to become obvious before carrying out internal fixation. Sixteen cases not included in the series had been treated by a combination of bone graft and some form of internal fixation: in six instances the wound broke down and infection caused delay in union. In deciding when to use internal fixation it was necessary to distinguish between 'open' and infected fractures, many civilian fractures could be classed as open. The golden rules were 1) meticulous wound toilet, 2) routine chemotherapy and maintenance of the haemoglobin level, 3) closure of the wound without tension, if necessary by skin grafting, 4) burial of metal under muscle, 5) absolute immobilisation of the limb until healing was complete.

**The Traumatic Unit**—*Mr C W B Littlejohn* (Melbourne) in his presidential address opened a joint discussion with the Section of Surgery and described traumatic surgery as the grandparent of all surgery. The development of surgery and traumatic surgery, the growth of industry, the enormous increase in traffic accidents and the lessons of two wars, had pushed this branch and its organisation to the forefront. In Great Britain much had been done and traumatic units which were developed in war-time now dealt with civilian casualties with continuity of treatment from the time of injury to final rehabilitation and resettlement in industry. In his view it was better to develop traumatic units in association with general hospitals rather than to establish new hospitals devoted to trauma as had happened in Birmingham, England. Traumatic units should treat all fresh cases of bone injury, infections of the hand and patients with residual deformity or interference with function by injury. It was unfortunate that insurance companies might not be interested in financing specialised traumatic units because they adjusted their premiums in accordance with liabilities.

**Rôle of the Plastic Surgeon in a Traumatic Unit**—*Mr B K Rank* (Melbourne) emphasizing the importance of primary skin healing in any case of open injury, considered that the part to be played by plastic surgeons was twofold: 1) the management of cases particularly appropriate to his practice including facio-maxillary injuries, many hand injuries, and all extensive soft tissue wounds including burns, 2) the treatment of many cases which hitherto had lain in "no man's land" and had often been handled indifferently in casualty departments. In compound fractures with skin loss local viability was the first consideration: it might be prejudiced by interruption of blood supply in raising a flap. There were two distinct principles underlying the design of local flaps—rotation and advancement: these were described with various applications. It was emphasized that plastic surgeons and orthopaedic surgeons should work side by side in traumatic units. In particular it was pleaded that the knowledge of plastic surgery now available should be utilised at an earlier stage.

**Hand Injuries**—*Mr B K Rank* (Melbourne) referred to the frequency in wounded men of stiffness of the small joints of the hand arising more often from inflammation, oedema and immobilisation, than from actual tendon or joint damage. The difficulties of secondary repair emphasized the importance of initial treatment of the injured hand in a special unit. Of 4604 injured workers entering the Casualty Department of the Royal Melbourne Hospital during 1947 more than one-third presented hand injuries. The main object of primary treatment was complete soft tissue closure, no matter how severe the injury or tissue loss, and no matter what tedium there might be to the surgeon. Not unless the highest standards of

primary healing could be expected was immediate repair of tendon or nerve injuries justified. Hand injuries might be considered in two categories. *'Untidy' hand injuries*—In these soft tissue wounds were often multiple of an angular or jagged type and with lacerated skin edges there might or might not be skin loss. The primary aim was soft tissue closure with split skin grafts, transposed flaps or primary direct flaps. In completing a traumatic amputation no more than was essential to effect closure should be removed because infected soft tissue from redundant parts might be of inestimable value in secondary repair. *'Tidy' hand injuries*—This type of case caused by choppers, knives, axes and glass, called for primary repair of all injured structures, provided only that there was no real likelihood that infection was already established. In two years at the Royal Melbourne Hospital no case of tendon repair, primary or secondary, had shown infection. Mr Frank discussed the work of Bunnell in America and Pulvertaft in England, and emphasized that: *a)* tendon repair was futile unless joints were mobile, sensation adequate, and scars absent from the region; *b)* operation must leave two clean and uninjured tendon ends in accurate apposition, the essence of atraumatic technique was more important than the particular suture material used; silk, nylon or stainless steel wire were all effective; *c)* in order to meet the danger of reactionary swelling the thermal sheath should be excised completely except for a few stirrups in appropriately placed positions to prevent prolapse; *d)* posture of the hand after suture was important; *e)* movement should be limited for the first three weeks and then begun in the inner range. There was no longer reason for a fatalistic attitude in relation to severed flexor tendons. If joints were mobile and sensation normal, a digit should not be amputated. It was urged that hand injuries should be segregated to the care of a few surgical teams in hospital. Only by long experience could a surgeon learn the pitfalls of hand surgery, and acquire the technique which would give a high percentage of good results.

## GREAT BRITAIN

### INSTITUTE OF ORTHOPAEDICS—POST-GRADUATE FEDERATION OF THE UNIVERSITY OF LONDON

The winter course of lectures and demonstrations in the Institute of Orthopaedics will be given at the Royal National Orthopaedic Hospital, Great Portland Street and the country branch, Stanmore, beginning on Monday, October 4, and continuing until Saturday, March 19, 1949, under the leadership of the director, Mr H. J. Seddon and the Dean, Mr H. Jackson Burrows. Each day there will be lectures in the basic sciences, clinico-pathological demonstrations, radiological and clinical conferences, demonstrations in the splint rooms and workshops and academic lectures in addition to the usual clinical practice of the hospital in wards, out-patient departments and operating theatres.

### BRITISH ASSOCIATION—110TH MEETING AT BRIGHTON, ENGLAND

The one hundred and tenth meeting of the British Association was held in Brighton from September 8 to 15, 1948. In his presidential address, Sir Henry Tizard discussed world food requirements. A discussion on human blood groups was held jointly by the sections of zoology, anthropology and physiology. Professor Le Gros Clark (Oxford), discussing the findings of the British-Kenya expedition in their study of the fossil remains of early Miocene apes, said that the Miocene period was estimated to have lasted about twenty million years before the Pliocene period which itself lasted for possibly thirteen million years. Of particular interest were some Miocene limb bones—humerus, clavicle, femur, calcaneus and talus—which had been discovered in this expedition for the first time. It was clear that these apes were not specialised for arboreal life but were capable of running and leaping with agility in marked contrast to the habits of modern anthropoid apes. The significance in relation to human evolution lay in the fact that hitherto many had argued that despite their apparent similarity limbs of human type could hardly have been derived from those which were characteristic of the modern anthropoid ape. To say the least the foundation of such argument is now disturbed.

Sir Henry Dale introduced a discussion on transmission of effects from the endings of nerve fibres and Professor F. R. Miller summarised the influences of eserine, acetylcholine and atropine on many varieties of synapses. There was much interest in Sir Ernest Rock Carling's discussion on the problems of old age and the revolt which he claimed was justifiable against the "sixty to sixty-five years convention" of retirement.

### INTERNATIONAL CONFERENCE ON SPEECH THERAPY

A conference on speech therapy attended by delegates from the Dominions, the United States of America, six European countries and two South American countries was held in the Royal Society of Medicine, London, in September 1948. The problems of speech disorder were covered in a series of thirty papers with detailed discussion on the dysphasia of Little's Disease, infantile paraplegia and head injury and the associated conditions of dysgraphia and dyslexia. It was a little disturbing to hear from

Dr Macdonald Critchley of the normal verbal mannerisms ' by which sentences are so often prefaced by such meaningless phrases as actually and "as a matter of fact" Dr Critchley said that as a rule women were more fluent than men but men took more interest in speech for its own sake. They deliberated over *le mot juste* and they thought of the *double entendre* in a way that women did not. Those of us who use dictaphones and are astonished thereafter to hear what we have said, and those of us whose speeches are recorded verbatim and are astonished at what we read may perhaps take solace in the fact that we are not alone in our verbal mannerisms. The work of speech therapists has not yet been granted the recognition it deserves but this conference demonstrated their pride in their work.

### ANNUAL CONGRESS OF THE CHARTERED SOCIETY OF PHYSIOTHERAPY

The annual congress of this Society was held in London from September 22 to 26 1948. After a reception at the Apothecaries Hall the opening lecture was given by Sir William Scott Douglas on the 'National Health Service'. Mr P. Bauwens gave a paper on "Electromyography". Mr H. Osmond-Clarke discussed 'Rehabilitation of the Injured'. Suspension exercises were discussed by Mrs Guthrie-Smith. Mr I. S. Smilie gave a lecture on 'The Quadriceps Muscle in relation to recovery from Knee Joint Injuries'. The Founder Lecture was delivered under the chairmanship of Lord Horder by Professor L. J. Witts on "The Experimental Approach to Physiotherapy". A reception was held at the Guildhall by the Rt. Hon. the Lord Mayor of London.

## INDIA

### ASSOCIATION OF SURGEONS OF INDIA

The ninth annual conference of the Association of Surgeons of India was held at Bombay. Dr M. G. Kini of Madras (M Ch Orth. Liverpool F R C S Edin.), was elected president. In his presidential address he discussed medical education and a suggested scheme for the reformation of Indian medicine with observations on specialisation in surgery and training in operative technique. He discussed the role of pathologists in surgical teaching and made an appeal for the development of a post-graduate college.

## BRAZIL

**Unusual Disruption of the Pelvis**—At the seventh Brazilian Convention of Traumatology and Orthopaedic Surgery an unusual disruption of the pelvis was reported by Dr Eneas Balesdent and Dr Roberto Neves. The patient, a man aged twenty-eight years, was thrown from his horse, sustaining a



Disruption of pelvis with overlapping of pubic bones reported by E. Balesdent and R. Neves (Brazil)

fractured clavicle, ruptured urethra and complete dislocation of the ilium with sacro iliac diastasis and overlapping of the pubic bones. The dislocation was reduced five hours later. The patient was placed on a wheeled stretcher with a sandbag under the sacrococcygeal region. The hips and knees were flexed and each lower limb was rotated outwards. At the same time two assistants, holding each ilium, moved them outwards and backwards by pressing on the anterior-superior spines. Complete reduction was accomplished at the second attempt. Three months later the patient was able to ride again.



## EGYPT

## EGYPTIAN ORTHOPAEDIC ASSOCIATION

An Egyptian Orthopaedic Association has been established under the first presidency of Professor M Kamel Hussein (I R C S England M Ch Orth Liverpool Professor of Orthopaedics in the University Farouk Cairo). The executive committee includes Professor Gawad Hamada (M B Ch B Birmingham Professor of Orthopaedics in the University Farouk Alexandria) and Dr Ali Mohamed (M Ch Orth Liverpool, surgeon at the Demerdache Hospital Cairo). The founder members include Dr A M Menaisy (I R C S England, and Dr A H Sharkawy (I R C S England both of whom are assistant professors in the University of Cairo, Dr Mansour Shawky (Red Crescent Hospital Cairo) Dr Philip Salub (Red Crescent Hospital Cairo) Dr Rached Iskander (Public Health Hospital Cairo) Dr Mohamed Mehrez (Demerdache Hospital Cairo) Dr Ali Chahed (Kings Hospital Cairo) Dr Kand Wahib (Ministry of Education Cairo), Dr Edward Saddek (Director of Helwan Sanatorium Cairo) Dr Abdou Sallam (Director of Marine Sanatorium Alexandria) and Dr Ahmed Hamam (I R C S England Hospital Cairo).

## SPAIN

## SOCIEDAD ESPANOLA DE CIRUGIA ORTOPEDICA Y TRAUMATOLOGIA

The annual meeting of the Spanish Association of Traumatic and Orthopaedic Surgery was held in Madrid on May 17 and 18 1948 under the presidency of Dr M Salaverré. Dr M Salaverré (Bilbao) was elected president. Dr R San Ricart (Barcelona) vice president. Dr C Gonzalez (Madrid) secretary, and Dr A Garzizabal (Madrid) treasurer. Scientific and clinical contributions were read.

**Treatment of Scoliosis**—Dr J Tironoso (Vigo) and Dr San Ricart (Barcelona) emphasized the importance of better understanding of the pathology of scoliosis in order that more logical treatment might be established. The etiology was often obscure but in some cases light could be thrown on the problem by study of the history. Anatomical cure of established scoliosis was almost impossible but in about 70 per cent of idiopathic cases clinical cure could be achieved by conservative methods. In childhood Steindler's conservative methods were found to be the most satisfactory especially for idiopathic and rachitic scoliosis, in such patients treatment might be expected to give successful results in 100 per cent of cases. Established scoliosis demanded treatment in specialised clinics under skilful direction. Spinal fusion, after maximal correction by the turnbuckle plaster jacket was the best treatment. Gymnastic exercises and plaster jackets were valuable auxiliary methods but they could achieve little by themselves. Real advance would be achieved only when it became recognised that operation was imperative if conservative measures failed to arrest progress of the deformity. Dr Fernandez Iruegas (Madrid) agreed as to the efficiency of Risser's method when combined with spinal fusion. Dr Salaverré (Bilbao) advocated conservative methods of treatment.

**Kuntscher's Intramedullary Nail**—Dr F Jimeno Vidal (Barcelona) summarised the historical background of the technique of intramedullary nailing and the evolution of this method of treatment since it was first introduced in 1940\*. The present situation in Germany made it difficult to study late results and it was therefore important to collect as much information as was possible from cases treated in Spain. He discussed the mechanical problems which arose and the measures of technique which were demanded for their solution. He reviewed also biological aspects especially alterations in bone physiology and the problems of bone infection. He disagreed with Kuntscher's opinion that callus formation was stimulated by nailing. His experience with intramedullary nailing in the upper limb was disappointing. He believed that nailing should be limited to the treatment of oblique and transverse fractures of the middle and upper third of the shaft of the femur. In other regions the indications were few and cases should be chosen with the utmost care. Intramedullary nailing was not indicated in children. Dr F Lopez de la Garma (Madrid) reviewed his experience of intramedullary nailing of lower limb fractures. In fractures of the shaft of the femur the results were excellent in 94.1 per cent of cases. In fractures of the shaft of the tibia there were 84.5 per cent of good results. The time of bone healing was shorter than with other methods. Most patients could be allowed to resume weight-bearing at an early date. Dr Garcia Diaz (Oviedo) expressed optimism he said that in all cases the fracture site should be exposed and the nail introduced under direct vision. Dr Sierra Cano (Santander) suggested that the nail should be used in treating pathological fractures. He showed several cases of fracture through the site of malignant bone tumours in which nailing had made the patient more comfortable and had relieved him of pain during the period of his survival. After the discussion a commission was appointed to study all cases treated in Spain by the Kuntscher method of intramedullary nailing. It was estimated that at least five hundred cases would be available for study.

\* The fact is that it was introduced by Hey Groves Bristol England before 1920—Editor



**Other Communications**—*Dr Sanz Ibanez* (Madrid) reported the finding of poliomyelitic virus during the pre-paralytic period in the muscles of mice which had been inoculated experimentally. *Dr Salaverré* (Bilbao) presented seven cases of arthrogryphosis. *Dr Clavel* (Murcia) and *Dr Sanchis Olmos* (Madrid) showed two interesting cases of Leri's disease. *Dr Sanchis Olmos* showed good results from osteotomy of the femoral neck in the treatment of paralytic dislocation of the hip joint.

## UNITED STATES OF AMERICA

**William Darrach Memorial Lecture**—The first William Darrach Memorial Lecture was given on June 12, 1948 at the Einhorn Auditorium of the Lenox Hill Hospital, New York, by Sir Reginald Watson-Jones (London) on the 'Principles of Immobilisation and Mobilisation in the Treatment of Fractures'. The lecture was given on the same day and at the same hour, as a lecture which the late Dr William Darrach had planned to give as part of a course of instruction organised by the New York and Brooklyn Fracture Committee of the American College of Surgeons under the chairmanship of Dr Preston A. Wade, and contributed to by Dr Robert H. Kennedy, Dr Paul B. Magnuson, Dr Philip D. Wilson, and Sir Reginald Watson-Jones. Dr Preston Wade said: 'It is with sincere regret that we record Dr Darrach's recent death. In his passing the medical profession has lost one of its greatest figures. We of the New York and Brooklyn Fracture Committee will miss him since he was one of the founders of this committee and one of its most staunch supporters. Sir Reginald Watson-Jones said: 'Dr Darrach was more than a great surgeon. Even across the Atlantic we knew him as 'Uncle Bill'. He was a leader of men and made such an impression on his disciples and students that, through them, his work is perpetuated and multiplied so that it is in truth immortal.

**Death and Growth of Bone**—The Robert Jones Memorial Lecture at the Hospital for Joint Diseases, New York, was given on May 26, 1948 by Sir Reginald Watson-Jones (London) on the occasion of the annual Alumni Conference under the chairmanship of Dr Leo Mayer. Sir Reginald said that the cause of death of bone like that of any other tissue was loss of blood supply. The blood supply might be destroyed by fracture for example fracture of the scaphoid, by dislocation, for example dislocation of the lunate by a combination of fracture and dislocation, for example fracture-dislocation of the astragalus, by operative intervention with stripping of soft tissues from the bone, or by embolism or thrombosis of end arteries. The diagnosis was based essentially on the shadow of relative density. The possibility that there might sometimes be true increase in the density of dead bone was perhaps not yet finally excluded but in the vast majority of cases the density was no more than relative and the appearances of true density were attributable to optical illusions. The pathology was that of complete bone death with osteoclastic resorption on one side of the lamellae and osteoblastic deposition on the other.

Clinical applications depended on three consequences of avascular necrosis: fragility of bone which unless protected became deformed; slow union of fractures when one fragment was avascular, and late development of arthritis due partly to the deformity of crushed joint surfaces but still more to death of the overlying articular cartilage. Deformity arising from the fragility of avascular bone could be seen in coxa plana when weight-bearing was permitted in the treatment of Perthes' disease, in crushing of the lunate bone in Kienbock's disease and in flattening and crushing of the talus when weight was borne early after fracture dislocation with necrosis of the body. Slow union due to avascular necrosis was obvious in certain fractures of the neck of the femur and fracture of the scaphoid. Even in fractures of the shaft of the tibia the relation of slow union to avascular necrosis could often be proved by radiographs taken at the right time. Late arthritis due to avascular necrosis was still the most important source of failure in the treatment of dislocation of the hip and fracture of the femoral neck. The incidence was higher than many believed—and no series of reported cases which claimed to indicate the frequency of this complication, and the possibility of reducing it by one or other device of treatment should even be considered unless supported by at least five to ten years' follow-up of cases.

The relationship of avascular necrosis to Legg-Perthes' disease still presented problems for study. Examples were shown of avascular necrosis of the femoral head similar to those of Legg-Perthes' disease due to the trauma of dislocation of the hip and fracture of the femoral neck in children and manipulative reduction of congenital dislocations, early tuberculous arthritis of the hip, osteomyelitis of the upper shaft and neck of femur, local foci of chronic bone infection in the femoral neck. In other words many types of injury and infection might cause thrombosis of the epiphyseal vessels with resulting avascular necrosis. Typical Legg-Perthes' disease of idiopathic type was no more than one example of avascular necrosis due to metaphyseal lesions which were sometimes, but by no means always obvious in early radiographs.

Bone grafting was essentially a study in avascular necrosis. Sections of ordinary avascular bone necrosis due to injury and sections of transplanted bone, were in all respects identical. Important clinical observations arose when it was recognised that complete replacement of dead bone in Perthes' disease of the hip took not less than two or three years. Complete replacement of a whole thickness bone graft also took two or three years. Cancellous chip grafting with its apparently speedy bone formation, had led

investigators to believe that chip grafts did not die as whole thickness grafts did. In fact such grafts died in precisely the same way and this was proved by many sections. The only difference in their behaviour arose from the loose open wave structure of the grafts with their thin lamellae. Primary union might be accelerated by chip grafting but bony consolidation was no more rapid than after any other type of grafting. No matter how favourable the circumstances adult bone could not grow and mature in less than three or four months and even after cancellous chip grafting early application of shearing stresses could interfere with growth and cause non union. The one certain indication for cancellous chip grafting and for rigid exclusion of any fragment of compact bone was a fracture with potential infection. In such cases there should be no foreign body of any type neither screws plates nor dead compact bone.

This is the Robert Jones Memorial Lecture and it is a great honour and distinction to be allowed to pay tribute in this city to one of the world's greatest pioneers of orthopaedic surgery—my chief my teacher my philosopher, and my friend. He lived on from Hugh Owen Thomas a tradition of scientific study. But it was not this alone which accounted for his contribution to the orthopaedic surgery of the world. It was not for this reason alone that we lament the destruction by bombs of 11 Nelson Street Liverpool a destruction which was quite complete except for the surgery door above which a stone was still visible. 11 O.T. Surgery 1866. Robert Jones knew the art as well as the science of surgery. This aspect of treatment now known as rehabilitation was his greatest contribution. L.M.

### CORRESPONDENCE

**Arthrodesis of the Ankle—Experiences with the Transfibular Approach**—In the August 1948, British issue of this Journal an editorial footnote was appended to Mr J. Crawford Adams' article on 'Arthrodesis of the Ankle Joint by the Transfibular Approach'. We wrote: 'To this day none of us knows with certainty who first conceived the brilliant idea of this simple and effective operation. Neither does any of us believe that it is important to attach the name of a single surgeon to a particular operation.' So far so good. But we went on to say that if credit must be attached it should be shared by certain young surgeons whose names were enumerated and in so doing we regret very much that the important priority of Dr Thomas Horwitz of Indianapolis, Indiana, was overlooked. He writes: 'Respecting your own thoroughness and the exactness of your British colleagues several of whom were my dear friends in the Middle East in 1942–44 and appreciating the superb merit of your issues of the Journal, may I call your attention to "The Use of the Transfibular Approach in Arthrodesis of the Ankle Joint" American Journal of Surgery, 1942, volume 55, page 550. We are grateful to you, Dr Horwitz, not simply because you have drawn our attention to your publication but still more because in your article you indicated the gradual evolution of this principle from the work of Goldthwait in 1908, Gattalier in 1931 and Alldredge in 1940. The advance of science is on so broad a front that, no matter what branch is considered, progress can seldom be measured in terms of the contribution of any one individual. Almost invariably it is shared by many.'

**"Infections of the Hand"**—In commenting on the article on "Infections of the Hand" by J. B. Loudon, J. D. Miniero and J. C. Scott published in the August number of the Journal (Vol. 30-B No. 3, 409) Mr J. F. Curr whose statistics were quoted says that 'a somewhat broad deduction has been made when it was reported that his cases were treated with local and systemic penicillin. The fact is that many of his cases were treated without benefit of penicillin and in certain other respects the speed of recovery in his cases may have been somewhat under-estimated. It is uncertain that there has been any serious mis-statement of fact but we take satisfaction in the knowledge that Mr J. C. Scott and Mr J. F. Curr are now in correspondence with each other.'

**Death while Bathing**—A correspondent to the columns of the British Medical Journal, Dr G. L. Alexander of Bristol, writes: "It would be interesting to know whether some unexpected deaths while bathing might not be due to acute prolapse of an intervertebral disc. About a year ago in my bath I was suddenly as it seemed cut nearly in two by something from behind. For ten minutes I lay in that bath paralysed and nearly fainting with pain. Had this happened while bathing alone in deep water I should certainly have died." The diagnostic significance of low back pain 'of immobilising intensity' is of course well recognised but few of us have stopped to think of all the possible circumstances in which such immobilisation might occur.

### ACKNOWLEDGMENTS

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# Book Reviews

TEXT-BOOK OF THE RHEUMATIC DISEASES Edited by W S C COPEMAN O B E , M D , F R C P  
Physician to the Rheumatism Department and Lecturer in the Medical School, West London Hospital  
Compiled by twenty-four contributors 10×7½ in Pp viii+612 with 351 figures some in full colour  
Index 1948 Edinburgh E & S Livingstone Ltd Price 50/-

Study of the rheumatic diseases is complex because it is not based upon one pathological process as in tuberculosis nor upon a narrow regional distribution as in gynaecology. The feature which links all these diseases is social rather than clinical and comprises the element of crippling disability for which they have a high potentiality. While the disabilities are largely in the locomotor system this subject has ramifications far beyond the scope of orthopaedics. Examination of some of the titles in the present book will show how broadly based must be the vision of one who wishes to master the whole field ranging as it does from Rheumatic Fever (Lord Horder) and Chorea (Copeman) to Rheumatoid Arthritis (L S P Davidson) Osteoarthritis (T E D Fletcher) Gout (Henry Cohen) Fibrositis (Copeman) and Sciatica (F A Elliott) not to mention some of the more rare arthritic syndromes. While therefore, at least 50 per cent of the work of an orthopaedic surgeon merits discussion under the term rheumatic disease, nevertheless he should realise that the full scope of rheumatism requires consideration of every system of the body and the whole of pathology. In diagnosis and therapy no single person can encompass the subject. We are driven to the conclusion that no new specialism is required in the attack upon rheumatism. In fact there is here a lesson for medicine as a whole as emphasized by Walshe namely the need for integration the development of team work and a return to the viewpoint of the 'physician'.

The present work is a striking example of integration for Dr Copeman himself a distinguished physician has gathered together a team of experts to present the many facets of his subject. He is to be congratulated on a review which is authoritative in a way which no work by a single writer could equal. Of particular note are the masterly contributions by Henry Cohen upon the 'Rarer Arthritic Syndromes' and Gout each is written in characteristic style with perfect clarity and complete understanding. It is inevitable that in a series of thirty essays there should be some overlap of material and repetition of detail. This fault however is much less than in many similar works by multiple authors. Most of the articles are enriched by valuable lists of references. In this way Henry Cohen's essays provide models, as also do the excellent sections on History by W S C Copeman Anatomy and Physiology by D V Davies Brachial Neuralgia by M J McArdle and Special Pathology by H J Gibson. The orthopaedic sections by Watson Jones and Osmond-Clarke are lacking in this regard. This is sad because in the space available they have not been able to deal exhaustively with this very large part of the therapeutics of rheumatic disease and reference to the work of other authorities some of whom they quote would have been of help. These two sections dealing respectively with the Principles and the Problems of Orthopaedic Treatment are however as one would expect first class and give a very fair outline of orthopaedic methods. One would perhaps have preferred a clearer exposition of joint posture in relation to function and physiological rest. The discriminating reader will not be influenced unduly by the tendency of the Watson-Jones school to regard arthrodesis of the hip joint as the 'ideal' operation for unilateral osteoarthritis even in young people. Good as the operative result may be, it is a misuse of the word to call it ideal. Nevertheless these quibbles do not affect our appreciation of the excellence of this contribution.

Apart from those articles already mentioned there are contributions by Sir Adolphe Abrahams on Differential Diagnosis C W Buckley on Spondylitis H A Burt on Physical Therapy Campbell Golding on Radiology J H Kellgren on Pain G D Kersley on Hydrotherapy L C G Pugh on Climatology Oswald Savage on Dermatology B Schlesinger on Still's Disease P Stocks on Statistics W Tegner on Social Problems Henry Wilson on Psychiatry, and B W Windeyer on Radiotherapy. In a work which deals with so much of general medicine it would be easy to find some little problem which has been omitted yet it seems to us strange that practically no mention is made of the neoplastic conditions of synovial membrane nor any discussion of senile decalcifying spondylitis.

This new text-book will clearly for a long time be recognised as the standard British work upon the rheumatic diseases. In future editions of which doubtless there will be many we hope that a little pruning elsewhere will permit a rather more ample discussion of orthopaedic principles and practice. As it is the work is a credit of distinction both to the publishers and to the notable team which Dr Copeman has assembled.—Norman CAPENER

TREATMENT BY MANIPULATION IN GENERAL AND CONSULTING PRACTICE By A G TIMBRELL FISHER M C M B F R C S, Orthopaedic Surgeon to the St John Clinic and Institute of Physical Medicine and to the Arthritic Unit St Stephen's Hospital. Fifth edition 9×6 in Pp xv+275 with 126 figures Index 1948 London H K Lewis & Co Ltd Price 25/-

In the fifth edition of this manual Timbrell Fisher has added many new sections to the text and has made his ideas more easily understood by the addition of many new illustrations.

The first chapter deals with the history of manipulation in the treatment of joint injury and disease.

and it attempts to explain the reasons for remarkable changes in the opinions of surgeons as to its value. The author wisely states that destructive criticism of manipulative treatment is of little value and that the subject must be taught from the basis of underlying pathology, a knowledge of which must form the basis of treatment. The outstanding feature of the work is the clarity of description of the type of injury, or the sequel of disease which can be treated successfully by manipulation. Contra-indications are given clearly and the complications which may result from its unjustifiable use are stressed firmly.

Included in this excellent material there are unfortunately some points to which exception might be taken. In the discussion on manipulation of joints the author suggests that an equally successful result can be obtained by manipulation whether the adhesions causing limitation of movement are intra-articular or extra-articular. Most of those who have experience with this method of treatment have found that the response to manipulation is much more satisfactory when adhesions are in the tissues round the joint and do not affect the joint lining or the articular surfaces. Again the author in his discussion of low back pain and sciatica wisely stresses the fact that surgeons must bear in mind the possibility that such pain may be due to retropulsion of the nucleus pulposus. Directly afterwards however he describes methods of manipulation and stretching of the sciatic nerve without indicating whether this method is to be used when retropulsion is deemed to be present. One other point might be noted in the illustration of manipulation of stiff terminal interphalangeal finger joints: movement is being produced by the pressure of the surgeon's fingers on the nail of the affected finger. If this method is used to bend a really rigid terminal joint the result as a rule is the development of a haematoma under the patient's nail which renders subsequent physiotherapy impossible, thereby losing the movement gained.

This book can be studied with benefit by any surgeon who is interested in this branch of the work. Much can be learned from this sensible presentation of a subject which to most people is still a mystery.—  
T. P. McMURRAY

**HUMAN PHYSIOLOGY** By I. R. WINTON M.A. M.D. D.Sc. Professor of Pharmacology University College London and L. E. BAYLISS Ph.D. Lecturer in Biophysics University of Edinburgh. Third edition.  $9\frac{1}{2} \times 6\frac{1}{2}$  in. Pp. vi+592 with 248 figures. Index. 1948. London J. & A. Churchill Ltd. Price 25/-

In this edition a number of physiologists have tried to co-operate in writing an elementary text-book in which the various branches of the subject would be presented to the student with the right emphasis. As a text book of physiology the book is not entirely satisfactory because too much space has been devoted to the central nervous system and the special senses and too little, for example to the cardio-vascular system. The undergraduate is likely to gain an unbalanced view. The book may be useful to post-graduates who want to refresh their memory of the facts of elementary physiology without being able to spare time to read one of the large text books. In this respect the usefulness of the book is limited by the omission of references to further reading.

The text is easy and for the most part clearly written but some of the diagrams are unnecessarily complicated. An attempt has been made to present the subject from the point of view of human physiology and this has been fairly successful. Nevertheless the book may not prove to be of great service to post-graduates.—John L. D. SILVA

**EARLY AMBULATION AND RELATED PROCEDURES IN SURGICAL MANAGEMENT** By Daniel J. LEITHAUSER M.D. F.A.C.S. Chief of Surgery St Joseph Mercy Hospital, Detroit Michigan.  $9\frac{1}{2} \times 6\frac{1}{2}$  in. Pp. vi+232, with 36 figures. Index. 1947. Oxford Blackwell Scientific Publications Ltd. Price 25/-

The purpose of this monograph is to impress upon surgeons the importance of early walking after abdominal operations. From an experience of more than 2000 patients the author asserts that if correct surgical procedures have been employed early walking is entirely without danger: it reduces the incidence of pulmonary atelectasis and thrombo-phlebitis, shortens the period of stay in hospital and diminishes post-operative disability.

It is recommended that as soon as the patient recovers from the anaesthetic (about three hours after operation) he is carefully assisted out of bed, made to cough in the standing position and encouraged to walk round the bed. It is emphasized repeatedly that coughing is more valuable when the patient is standing than when he is sitting or lying. In cases of incipient atelectasis it is usually possible to detect palpable rales at the pulmonary bases when the patient stands after a bout of coughing; a plug of mucus is expelled and the rales disappear. Whenever atelectasis is suspected coughing in the standing position is repeated at two-hourly intervals. The only contra-indications to early walking are severe shock and a large mid-line vertical scar. Continuous intra-abdominal suction is not a contra-indication in fact after

cholecystectomy the author gives continuous suction and disconnects the nasal tube from the suction apparatus when the patient gets out of bed. Types of incision and the nature of suture material are discussed. Transverse or oblique incisions are generally recommended. Mid-line and particularly mid-rectus incisions are believed to predispose to wound disruption and post-operative hernia. Fine chromic catgut is used for the peritoneum and extra-peritoneal fascia and alloy steel wire for other layers and the skin.

The average length of stay of patients in hospital after operation was: appendicectomy (795 cases) 2.26 days; cholecystectomy (180 cases) 7.4 days; repair of hernia (200 cases) 5.7 days; pelvic operations (176 cases) 6.3 days. In a series of 2700 cases there were only fourteen fatalities, in none of which could death be attributed to early walking. Incipient pulmonary atelectasis occurred in four cases, post-operative pneumonia in two and thrombo-phlebitis in two. Disruption of the abdominal wound did not occur. Twelve hernias recurred.

The author puts up a good case for early walking. Nevertheless, in anxiety to drive his points home he tends to lecture the reader. There is a good deal of repetition even to the extent of allowing the same sentence to appear in consecutive paragraphs. The book is well produced and well illustrated.—H. A. BURT

**TEXT-BOOK OF ANAESTHETICS** By R. J. MINNITT M.D. (Liverpool) D.A. (R.C.P. & S. Eng.), Senior Honorary Anaesthetist Royal Liverpool United Hospital, Liverpool Maternity Hospital and Birkenhead Maternity Hospital; Director of Anaesthetics, David Lewis Northern Hospital, Liverpool and John GILLIES M.C. M.B. Ch.B. (Edin.) F.R.C.S. (Edin.) D.A. (Eng.), J. Y. Simpson Lecturer in Anaesthetics, The University of Edinburgh; Director, Department of Anaesthetics, Edinburgh Royal Infirmary; Consultant in Anaesthetics, Department of Health for Scotland. Seventh edition. 9×6½ in. Pp. vii+568 with 229 figures. Index. 1948. Edinburgh: E. & S. Livingstone, Ltd. Price 30/-

The seventh edition of Minnitt and Gillies will be welcomed warmly by all who teach anaesthesia because the previous edition which has been out of print for some time, was unquestionably the best text-book for undergraduates extant in this country. The new version is much enlarged—568 pages as against 497 and with 229 illustrations instead of 199. The figures are clear and well chosen, some being in colour.

There is no need to make detailed reference to the teaching which is sound throughout. It has been brought up to date by a chapter on the use of curare by Dr T. C. Gray. The section on local analgesia by Mr L. B. Wevill has been extended and it is now of much use as a practical guide in technique, as also is the subsection devoted to applications in dentistry by Professor John Boyes. Some of the legal aspects of anaesthesia have been dealt with by J. Crossley Vaines who is a Master of Law.

A few minor criticisms might be made. Abbreviations are not always those which are officially recognised: for example gm for g and "cc" for "c.c.m." Moreover, the nomenclature is not uniform: the term millilitres is sometimes substituted for cubic centimetres. The only technical advice which is open to criticism is that which relates to the administration of strychnine in cocaine poisoning. The literary style is usually excellent, and the book can be recommended whole-heartedly as a sound basic guide. The paper, printing and binding are well up to the high standard which is now expected of Messrs E. & S. Livingstone Ltd.—C. Langton HEWER

**NOTES ON THE NEUROSURGICAL NEEDS OF THE POPULATION AND THE TRAINING OF THE NEUROSURGEON** 5½×8½ in. Pp. 34. Published by the Society of British Neurological Surgeons.

The last war brought a striking increase in the number of beds available for neurosurgery. The planning committee of the Society of British Neurological Surgeons (Sir Hugh Cairns, President) now suggests the provision of one neurosurgical centre of fifty to sixty beds per million inhabitants, most usefully situated in close proximity to a university and teaching hospital. Country hospitals are good only for convalescence or chronic maladies requiring little medical care. It is improbable that the number of neurosurgical beds in a thousand-bedded teaching hospital could exceed forty. The committee, however, is convinced that neurosurgery is a proper subject for the clinical training of students because it furnishes admirable lessons in applied physiology. Much that is wise as well as stimulating is contained in the recommendations on the necessary qualifications and training of the neurosurgeon. The creation of a special Diploma in Neurosurgery is felt to be undesirable. The report stresses the close relationship between neurological surgery and other branches of medicine and surgery. Orthopaedic surgeons in particular, will derive considerable information and mental stimulation from its study. It is interesting to note, for example, that in an analysis of 32,491 admissions to fourteen centres between 1940 and 1945 there were 2627 cases of sciatica and 795 spinal tumours.—W. R. BETT

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